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How to identify policies that genuinely complement an economy-wide carbon price

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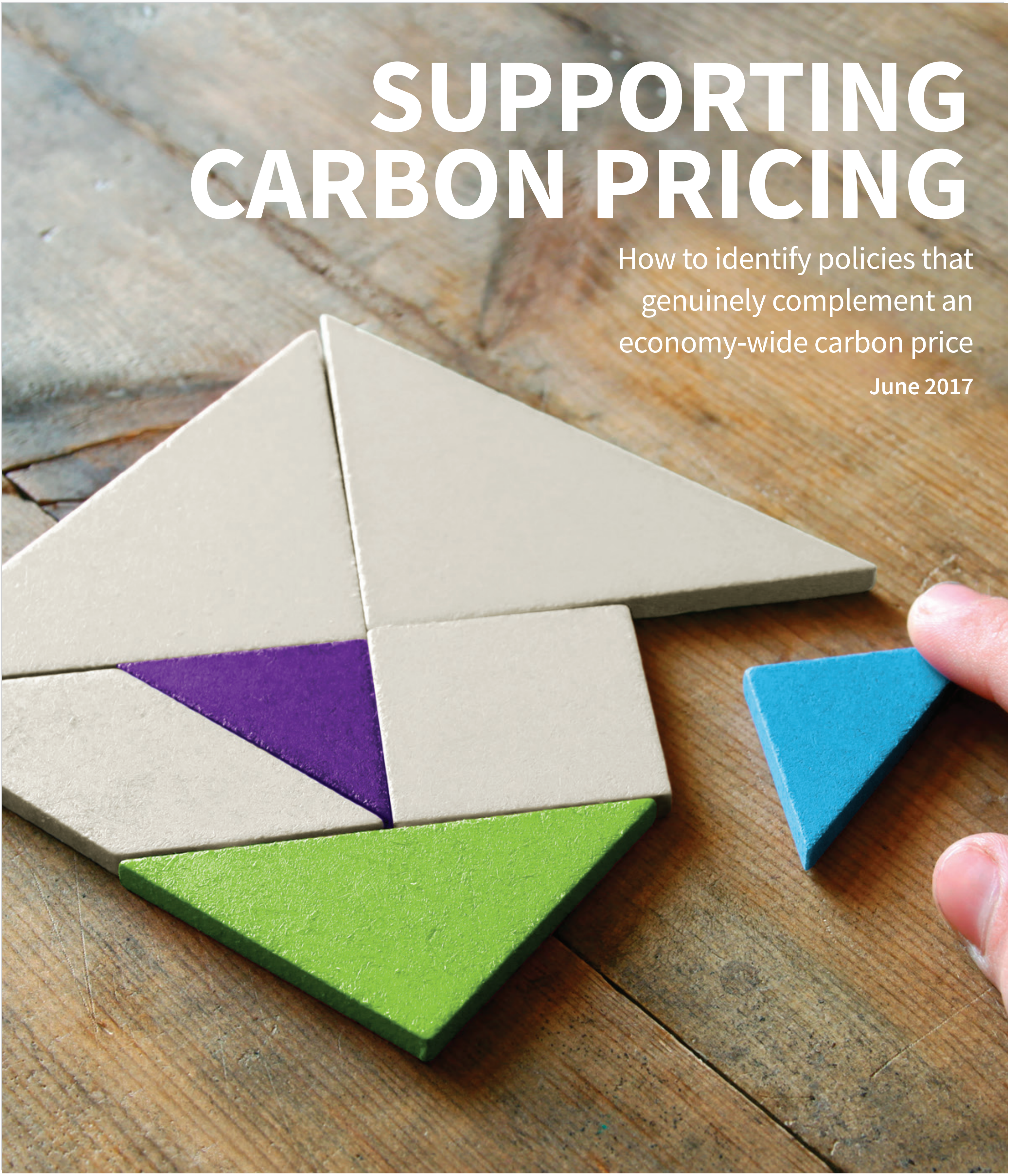

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EXECUTIVE SUMMARY

In December 2016, Canadian governments announced the Pan-Canadian Framework on Clean Growth and Climate Change. Under the framework, Canada will have nationwide carbon pricing in 2018, with prices rising until 2022. This is welcome news. As previous reports from the Ecofiscal Commission have argued, an increasing carbon price should be the centrepiece of each province's and territory's plan to reduce greenhouse gas (GHG) emissions. Yet for Canada to achieve its 2030 emissions-reduction targets in a cost-effective way, more will be needed.

As the Ecofiscal Commission has argued previously, carbon pricing should be trusted with the heavy lifting. It offers the most cost-effective way to reduce GHG emissions. It is flexible. It generates revenue that can be used to reduce other taxes or drive other benefits. And it drives low-carbon innovation. A carbon price that continues to rise beyond 2022 is therefore a key piece of the policy puzzle.

However, even well designed carbon pricing can have limitations. Some GHG emissions are difficult to measure and price in practice. In some situations, specific market barriers might undermine the incentives from a carbon price and limit the extent to which it drives low-cost emissions reductions. And where GHG reductions are costly but come with offsetting, non-GHG benefits, the incentive from carbon pricing might not be enough. These issues can justify non-pricing climate policies as part of a larger policy package.

The best additional policies *complement* carbon pricing, driving more emissions reductions at a lower economic cost than carbon pricing can on its own. But simply adding more climate policies to the mix will not necessarily improve performance. Smart policy makes both environmental and economic sense. If additional policies are not chosen and designed well, they can *increase* costs of GHG mitigation.

Identifying and designing effective, low-cost non-pricing policies is therefore a critical, but complex task. It raises challenging questions: What makes a given policy genuinely complementary to the carbon price? Which policies help achieve low-cost GHG emissions reductions, and which ones hinder? And how can governments ensure that they rely more on the former, and less on the latter?

This report is intended to help governments identify, design, and implement a package of complementary policies that can support their carbon prices. Developing a coherent and low-cost policy package is not easy, but it is worth the effort: with the right package, governments can make their carbon prices work better, and Canada can reduce its GHG emissions cost-effectively. But to get it right, some careful work will be required.

Complementary policies fill a role that carbon pricing cannot

Policies could have any of three distinct rationales for being implemented in addition to carbon pricing:

***Gap-filling* policies apply to GHG emissions not covered by the carbon price.** Some GHG emissions do not lend themselves so easily to carbon pricing. In particular, emissions from small, distributed, non-point sources can be challenging to measure, even though actions to reduce these emissions might have quantifiable outcomes. Extending the overall coverage of a package of policies to more GHG emissions can *reduce* costs of achieving a GHG target.

Our case study on regulations for methane emissions from oil and gas production, for example, highlights an opportunity for substantial emissions reductions. Methane emissions are not currently covered by carbon pricing policies, but reducing these emissions appears to be possible at relatively low cost.

***Signal-boosting* policies can address market problems and thereby enhance carbon pricing.** A carbon price works by relying on price signals in markets—not governments—to decide where and how GHG mitigation occurs. In some specific cases, however, carbon pricing might not work to its full potential, given other problems in the market. As a result, policies that address these problems can make economic sense. In the absence of a clear rationale for policy, however, policies risk being driven purely by political or lobbying interests.

Our case study on subsidies for electric vehicles, for example, identifies specific market problems that *may* justify additional policy measures. There may be benefits to society from scaling up electric vehicles, such as enabling networks of charging stations or demonstrating that the technology works. On the other hand, a smaller or slower response to carbon price signals does not necessarily justify the creation of additional policies. Slower uptake of electric vehicles could also represent real underlying costs and preferences. As our case study indicates, the mere existence of these problems is not enough to justify a policy response. The benefits of overcoming these market problems must outweigh the costs of doing so. We find electric vehicle subsidies to be a high-cost approach relative to other policy alternatives.

***Benefit-expanding* policies achieve both GHG mitigation and other objectives.** Other benefits, unrelated to GHG emissions reductions, might justify policies that drive relatively costly GHG emissions reductions. Still, policymakers should be wary of policies with ambitions of "killing two birds with one stone." Relying on a single instrument to achieve multiple objectives often means that *none* of the objectives are achieved at lowest cost.

Our case study of the phase-out of coal-fired electricity suggests that reducing air pollutants in conjunction with GHG emissions can lead to significant health benefits, and that these benefits help offset some of the costs of reducing GHGs under the policy. Our case study suggests coal phase-out in Alberta could have health *benefits* equivalent to about \$21 per tonne of CO_2e reduced.

Policies will interact with carbon pricing in different ways in different provinces

Interactions between climate policies can reduce effectiveness, and can also increase overall costs. These issues can be particularly challenging in terms of interactions between federal and provincial policies.

Adverse interactions can occur when multiple policies apply to the same sources of GHG emissions. Complementary policies might target emissions also covered by the carbon price. Provincial and federal policies might apply to the same sources of GHG emissions. Unless these overlapping policies have another rationale—addressing market problems or driving other co-benefits—they will increase overall costs, and may not drive additional emissions reductions. Gap-filling policies are less prone to interaction problems, because they apply to emissions not covered by the carbon price.

In particular, additional policies that apply to emissions covered by a cap-and-trade system will tend not to lead to additional emissions reductions overall. While the policy may lead to additional emissions reductions *within a given sector*, the total number of permits in the system—and thus the total allowable number of emissions—remains unchanged. As a result, emissions reductions from the additional policy can be offset by higher emissions elsewhere in the cap-and-trade system. In the case of Ontario and Quebec, the outcome may be fewer permit imports from California through their linked permit markets, but not necessarily lower emissions overall.

These issues become even more complex in the context of multiple policies from multiple levels of government, where there is significant variation across provinces. As a result of interaction effects, complementary policies can create uneven impacts across provinces. Federal policies that overlap with carbon pricing policies will drive additional emissions reductions in provinces with carbon taxes, but not necessarily in provinces with cap-and-trade systems. Moreover, in provinces with cap-and-trade systems, provincial policies could contribute toward emissions reductions required under the cap, making it "easier" to achieve. These different impacts could raise challenging questions about how the burden of GHG mitigation is distributed across provinces. It could also increase differences in carbon prices across provinces, increasing the overall cost of mitigation in Canada.

Design choices strongly affect the performance of complementary policies

Even if a policy has a strong rationale for complementarity and does not interact adversely with other policies, it still might not perform well if it is designed poorly. Well-designed policies will generally drive more emissions reductions and have lower costs. When it comes to policy performance, five design features are particularly significant: *stringency, coverage, flexibility, predictability*, and *governance*.

Stringency is the extent to which a policy drives emissions reductions. More stringent policy is more effective policy, but may also create higher compliance costs for governments, businesses, or households. For example, the stringency of a policy to phase-out coal-fired electricity is defined by the timeline for phase-out—the more aggressive the timeline, the more stringent the policy. Canada's 2012 federal regulation of coal-fired electricity called for coal plants to close or be retrofitted with carbon capture and storage only at their "end-of-useful-life." However, in November 2016, the federal government announced a policy with far greater stringency—the phase-out of *all* coal-fired electricity by 2030. This roughly mirrors the timeline that Alberta is planning for its own phase-out of coal, a policy examined as a detailed case study in this report.

Coverage refers to the share of GHG emissions to which a policy applies. A policy with narrow coverage will focus on a specific sub-set of technologies or activities (e.g., a regulation focused only on fuel-oil furnaces), while a policy with broader coverage will focus on the larger set of technologies or activities (e.g., a regulation focused on all types of home-heating technologies). All else being equal, broader coverage means greater emissions reductions and lower costs. Yet there may be good reasons to keep coverage narrow in certain cases. If there is a specific market problem to be overcome with signal-boosting policy, or a specific co-benefit to be realized, these outcomes might be more cost-effectively realized with a tightly focused policy. Broader policies may also overlap (and interact) more with carbon pricing policies.

Flexibility generally refers to the extent to which emitters have choices regarding how they comply with a policy. Policies that emphasize flexibility typically focus on outcomes (i.e., performance standards) rather than means (i.e., specific technologies or activities). As a result, flexible policies tend to have lower costs than prescriptive policies. Flexibility can be introduced through market-based mechanisms such as credit trading, banking, and borrowing. For instance, zero-emission vehicle (ZEV) mandates, such as the policy implemented in Quebec, require manufacturers to produce and sell a certain number of zero-emission vehicles. Flexibility—through trading permits—allows firms with low costs to produce and sell the ZEVs, and to sell excess permits to firms with higher compliance costs. Indeed, our case study on electric vehicle subsidies suggests that flexible regulations might be a more cost-effective approach to increasing ZEV uptake.

Predictability is the extent to which a policy establishes clear incentives over the longer term. It has three main dimensions: 1) *transparent* policies clearly lay out how the policy will work and the criteria under which changes to it might occur; 2) *credible* policies exist when firms and households are confident governments will consistently implement, enforce, and maintain the policy over time; and 3) *simple* policies are easy to understand, both now and in the future.

Firms' and households' expectations about future policy will affect their investment choices and their incentives to innovate. As a result, predictability has implications for both policy effectiveness and cost-effectiveness. For example, if oil and gas producers expect that their methane emissions will be subject to more stringent regulation in the future, they may choose a higher standard of leak-detection technology for projects they are currently planning. The policy's predictability makes it more cost-effective: the firm does not need to install one type of technology now and another when the regulation is announced in the future. Predictability in this example also increases effectiveness: firms reduce emissions earlier (possibly even in advance of the regulation taking effect) by adopting the superior technology in the first place.

Governance refers to oversight of the policy over time, including clear mechanisms for periodic review, improvement, and termination. Evaluating the performance of policies over time provides new information that can inform decisions about improving or terminating the policy. For example, Ontario's Feed-in Tariff program initially experienced an unexpectedly large uptake. Recognizing that the feed-in-tariff rate was likely higher than necessary, policymakers eventually reduced the rate, thereby improving the policy's cost-effectiveness. Notably, however, the Ontario government had ignored early warnings from the provincial auditor general about the tariff rate, suggesting shortcomings in the policy's larger governance procedures.

Applying our findings

Overall, we find that some—but not all—additional, non-pricing climate policies can genuinely complement carbon pricing. For these policies to contribute to an effective and cost-effective package of policies, they must be chosen and designed carefully. Truly complementary policies must 1) have a clear rationale; 2) not adversely interact with the carbon pricing policy; and 3) be designed well.

Given these findings, we make the following recommendations to Canadian provincial, territorial, and federal governments:

RECOMMENDATION #1:
Governments should make carbon pricing the core of their climate policy, with steadily increasing stringency

There is a role for non-pricing policies as part of an effective and cost-effective policy package for reducing GHG emissions. Yet to achieve reductions at lowest cost, these policies should *complement* rather than substitute for carbon pricing. The price of carbon should continue to rise—steadily, consistently, and predictably—beyond 2022 and well past $50 per tonne.

RECOMMENDATION #2:
Governments should clearly demonstrate complementarity before adopting non-pricing policies

More GHG policies do not necessarily make for a better climate strategy. Additional, non-pricing policies can increase costs and undermine the effectiveness of a carbon price. Policymakers should focus their efforts on policies that clearly have one of the three rationales explored in this report. They should fill gaps in carbon pricing policies, boost the signal of the carbon price, or generate significant co-benefits. Policies that do *not* fall into at least one of these categories will not be complementary to a carbon price. Governments should therefore *clearly demonstrate* the complementarity of proposed non-pricing policies prior to their adoption. This requirement can help limit high-cost policies. It can also limit undue influence from interest groups and industries seeking preferential treatment under prescriptive or technology-specific climate policies.

RECOMMENDATION #3:
Governments should strive to coordinate carbon pricing and complementary policies across the country

Over time, if differences between carbon prices across provinces and territories increase, pan-Canadian climate policy will have higher costs than necessary. Similarly, differences in complementary policies—and differences in interactions between carbon pricing and other policies—can increase overall costs. In both cases, the issue of inter-jurisdictional coordination and burden sharing is complex. All levels of government will continue to share jurisdiction over climate policy. Therefore, it is all the more important that they continue to cooperate to ensure that policies work together coherently.

RECOMMENDATION #4:
Governments should regularly review and assess both individual climate policies and the larger policy package

The many design details of complementary policies have significant implications for emissions reductions and the costs of achieving them. Interactions between policies add to the complexity of designing an overall package. And as this paper illustrates, identifying effective and low-cost complementary policies requires judgment and leaves room for debate. Identifying cost-effective signal-boosting policies can be particularly challenging, given uncertainty around the nature of potential market problems. As a result, no matter how carefully governments design a policy package, they should plan for regular review and assessment of its actual performance. Policy review and evaluation creates an opportunity for ongoing adjustment and improvement, and is always well advised—but especially so for complementary climate policies. Such “ex-post” analysis can provide critical insight into the coherence of the climate policy package, and how efficiently the burden of emissions reductions is being distributed across provinces and territories. Strong processes for review and adjustment to policies can create space for taking measured risks in implementing policy: high-cost or ineffective policies are less problematic in the long term if mechanisms exist to phase out those that perform less well in practice than theory. Governments can carry out this evaluation themselves, or they can choose to commission independent, objective evaluations of policy performance.

RECOMMENDATION #5:
Governments should rely on integrated modelling to assess the overall effectiveness of proposed and existing policies

This report highlights interactions between policies as a particularly thorny issue, especially in terms of their potential asymmetric impacts across provinces. These interactions clearly merit special attention. Indeed, the combined impact of federal and provincial climate policies should be regularly assessed. The means by which the interactions are assessed, however, is important. Only economy-wide, integrated modelling can provide a full examination of these effects.

To a limited extent, the federal government currently performs this function, through its annual Canada's Emissions Trends publication, which projects future Canadian emissions using Environment and Climate Change Canada's (ECCC) integrated modelling system, E3MC. Though not explored by this publication, ECCC's modelling system is well suited to take into account the interactions between policies. Future public analysis from ECCC could explore policy interactions in more detail. By comparing modelling analyses with and without overlapping policies, it could examine the significance of policy interactions between different policies at different levels of government, which would help in identifying opportunities for harmonization and coordination.

However, it may be more appropriate that this function be performed by an independent agency or commission, or new institutions providing oversight of the Pan- Canadian Framework. Notwithstanding the important governance issues to be resolved, making this type of analysis and assessment publicly available would improve transparency and accountability as Canada moves toward achieving its longer-term emissions-reduction targets.

RECOMMENDATION #6:
With the implementation of an economy-wide carbon price, governments should phase out and avoid redundant, high-cost, or ineffective policies

All Canadian governments should seek to identify and eliminate existing policies that no longer make sense given the implementation of economy-wide carbon pricing. In past years, these existing policies may have represented practical policy approaches in the absence of carbon pricing; today, they are unlikely to be either as effective or cost-effective as a broad-based carbon price. The emergence of pan-Canadian carbon pricing as a policy norm creates an important opportunity to shift toward more cost-effective policy by clearing the books of some older and higher-cost regulations and subsidies. Governments should only employ additional policies that are genuinely complementary to carbon pricing.

CONTENTS

1 INTRODUCTION

Canadian governments are moving on climate change. In October 2016, Canada formally ratified the Paris Agreement, with a pledge to reduce its greenhouse gas (GHG) emissions to 30% below 2005 levels by 2030. In December 2016, the federal and provincial governments negotiated the Pan-Canadian Framework on Clean Growth and Climate Change, an agreement that includes a national carbon pricing policy, starting at a minimum price of $10/tonne in 2018 and rising to $50/tonne by 2022 (Government of Canada, 2016a).[1]

This is welcome news. As we argued in *The Way Forward*, a broad-based and nationally harmonized carbon price is the best way for Canada to lower its emissions effectively and cost-effectively, and should therefore be the backbone of any economy-wide strategy to achieve emissions reductions (see Box 1 for more details). Yet for Canada to meet its existing GHG emissions-reduction targets, more policy action will be needed (Jaccard et al., 2016; Sawyer & Bataille, 2016).

A gradually rising carbon price is a central part of this story, but not the only part. Even well-designed carbon pricing has its limitations. Some GHG emissions are difficult to measure and price in practice. In some situations, specific market barriers might undermine the incentives from a carbon price and limit the extent to which it drives low-cost emissions reductions. And where GHG reductions are costly but come with offsetting, non-GHG benefits, the incentive from carbon pricing might not be enough. These issues can justify non-pricing climate policies as part of a larger policy package.

However, not all additional climate policies are created equal; some will help, while others will hinder the overall policy package. Individual policies might be poorly designed, they might interact with the carbon price in unfavourable ways, they might be ineffective at reducing emissions, or they might be effective but only at a high cost. Identifying policies that improve the overall policy package can be complex. This report seeks to help policymakers navigate the complexities of additional climate policies, and to help them to assess their merits objectively.

The remainder of this report is structured as follows. Section 2 defines key objectives for identifying genuinely complementary GHG policies. Section 3 explores the three main factors that policymakers should consider when assessing additional, non-pricing policies. Section 4 integrates these factors into a practical framework for the design and evaluation of policies. Section 5 puts the framework into action, applying it to three Canadian case studies. Section 6 provides guidance on how to design a coherent package of climate policies. Finally, Section 7 offers some conclusions and recommendations for Canadian governments.

[1] As of publication, only two provinces—Saskatchewan and Manitoba—had yet to sign on to the Pan-Canadian Framework.

This report does not identify or recommend the use of specific complementary climate policies. Rather, it focuses on the *process* of identifying the policies that can help us achieve our emissions-reduction objectives in the most cost-effective way. By helping to clarify the trade-offs among various policies, the Ecofiscal Commission hopes to stimulate a constructive and informed discussion regarding important policy choices.

Box 1: Carbon pricing as the most cost-effective way to lower GHGs

Carbon pricing is less costly than other approaches because it creates incentives for firms and households to identify and implement lowest-cost actions to reduce GHG emissions.

For example, consider a command-and-control regulation requiring high-efficiency home furnaces, in comparison to a carbon price. There are many ways residential energy efficiency can be improved, including changing thermostat settings; installing a heat pump; improving insulation; downsizing one's home; or installing a more efficient furnace. The regulation targets only one of these options, while the carbon price targets them all. By creating incentives across all these dimensions, carbon pricing allows homeowners to determine which responses make the most sense for them, and in the aggregate, allows the most cost-effective mitigation to emerge.

A second reason why carbon pricing is less costly is that—unlike command-and-control regulations—it generates revenue that can be used to drive other benefits (Canada's Ecofiscal Commission, 2016a). For example, revenue can be used to reduce existing personal or corporate income taxes. It can be used to fund critical infrastructure. Or, it can be used to address concerns around business competitiveness or household fairness.

Finally, carbon pricing is the most important policy instrument for driving low-carbon innovation (Popp, 2016). It creates a steady, predictable demand for technologies, now and in the future, that reduce more GHG emissions at lower cost.

The greater cost-effectiveness of carbon pricing is supported by research from around the world (OECD & World Bank, 2015; Parry et al., 2012). A number of studies have contrasted the cost-effectiveness of carbon pricing with other approaches, such as command-and-control regulations, performance standards, and subsidies for renewable energy. Overall, these studies have found that any policy acting as a substitute for economy-wide carbon pricing will be costlier than a carbon price (Fischer & Newell, 2007; Goulder & Parry, 2008; OECD, 2012; OECD, 2013b). This is why carbon pricing is often regarded as the "first best" approach for reducing GHG emissions (Twomey, 2012).

Furthermore, carbon pricing has also been shown to be effective at reducing GHGs. In 2008, British Columbia implemented the first carbon tax in Canada. In their review of the policy, Murray and Rivers (2015) find that the tax reduced emissions in the province by 5% to 15%. They find that these reductions were achieved with negligible effects on aggregate economic performance.

Regulations can be designed for cost-effectiveness by being technology neutral and incorporating flexibility (Jaccard et al., 2016), but such policies rarely—if ever—achieve the cost-effectiveness of carbon pricing. In some cases, policymakers might choose to proceed with policies other than carbon pricing, despite their higher costs (Bennear & Stavins, 2007). For example, politicians may pursue other policies that involve higher but less visible overall costs if they perceive limited political acceptability for stringent carbon pricing. The use of non-pricing policies as substitutes for carbon pricing is not the focus of this report. For more information on this topic, see Jaccard et al. (2016) and Canada's Ecofiscal Commission (2015).

2 CHALLENGES FOR COMPLEMENTARY CLIMATE POLICIES

This section situates the challenge of identifying complementary GHG policies in the current Canadian context. It establishes *effectiveness* (i.e., reducing GHG emissions) and *cost-effectiveness* (i.e., achieving reductions at the lowest cost) as overall objectives for both individual GHG policies and broader packages of policies. It also explains why other GHG policies might be required—in addition to carbon pricing—to achieve these objectives. Finally, it notes that some additional policies might undermine these objectives: poorly chosen or badly designed policies can increase the overall costs of the policy package.[2]

2.1 THE CANADIAN POLICY CONTEXT

We are entering a new phase of climate policy in Canada. So far, Canadian climate policies have existed in a patchwork. Some governments (such as in British Columbia, Alberta, Ontario, and Quebec) have already implemented both carbon pricing policies and other, non-pricing policies to reduce GHG emissions. Other governments, including the federal government, had to varying degrees focused on non-pricing policies. In many cases, these non-pricing policies offered an important way of getting started on climate policy. But with broad-based carbon pricing now expected in all parts of the country by 2018, it is critical to examine the role that these additional policies should play as part of a broader policy package.

Governments across Canada are in the process of designing and implementing such policy packages. The federal government has laid out its initial thinking on a set of policy measures it intends to implement, in collaboration with the provinces, in order to achieve its 2030 emissions objectives (Government of Canada, 2016a). And provinces are now considering how they will price carbon, and what additional policies might also play a role. We are at a critical juncture: If Canada is to cost-effectively achieve its existing emissions targets, we must get this policy mix right.

To ground our discussion in real-world policy, Table 1 describes three illustrative GHG policies being considered or implemented by various governments in Canada. None of the policies is itself a carbon pricing policy. Furthermore, each policy is being considered

[2] This is true of both complementary climate policies and carbon pricing—if a carbon tax or cap-and-trade scheme is poorly designed, it can undermine the effectiveness and cost-effectiveness of the larger policy package.

in a jurisdiction that already has a broad-based carbon price. These policies raise key questions about their role as part of an overall policy package: How effective are they at reducing GHGs? How do they interact with existing or planned carbon pricing policies? Are they a cost-effective way to reduce affected emissions? We will return to each of these policies as case studies in Section 5.

Table 1: Examples of additional, non-pricing GHG policies in Canada

Policy	Jurisdiction	Description
Regulating methane emissions in the oil and gas sector	Federal	Requires that oil and gas methane emissions be reduced 40–45% below 2012 levels by 2025
Electric vehicle subsidies	Quebec	Provides a subsidy of up to $8,000 for the purchase of new fully electric, plug-in hybrid, hybrid, or low-speed electric vehicles
Phasing out coal-fired electricity	Alberta	Requires the phase-out of all coal-fired electricity generation in the province by 2030

Additional policies can take various forms

The policies described in Table 1 are illustrative of the kinds of additional, non-pricing policies governments are currently considering. The list is clearly not comprehensive.[3] More generally, four main types of instruments make up the menu for non-pricing climate policies:

- **Regulations** require households, businesses, or governments to take certain actions to reduce GHG emissions. For example, regulations can require industry to meet specific GHG intensity targets (e.g., federal vehicle efficiency standards), require the adoption of a specific type of technology (e.g., various provincial building codes), or set limits on certain types of emissions-intensive industrial growth (e.g., Alberta's cap on oil sands emissions). Regulations might also include market-based mechanisms that allow flexible compliance (e.g., compliance trading in federal vehicle standards).
- **Subsidies** provide public funds to businesses or households to support specific actions to reduce GHG emissions. Subsidies can be used to reward specific outcomes or activities (e.g., Ontario's renewable feed-in tariffs that provide payments for each kilowatt-hour of renewable electricity generated). Or, they can have broader objectives, such as funding for research and development or technology deployment (e.g., Saskatchewan's government support for carbon capture and storage). The source of funds for subsidy-based GHG policies can vary, but using revenue from carbon pricing can be a common approach.[4]
- **Public investments** use tax revenues to purchase assets such as electricity grids, transportation infrastructure, and buildings that can enable emissions reductions (e.g., federal support for improved interprovincial electricity transmission). Electrical infrastructure and public transit are common areas for public investment—smart electricity grids can enable more renewable electricity, and public transit can provide alternatives to driving (e.g., increased support for public transit under Ontario's *Climate Change Action Plan*).
- **Information-based policies** provide information that helps households and businesses identify economically sensible choices that reduce GHG emissions (e.g., the federal EnerGuide labelling program requires manufacturers to provide information about the energy efficiency of appliances). When implemented at the firm and market levels, they can support GHG mitigation by making investment patterns more reflective of underlying climate risks (e.g., the Task Force on Climate-Related Financial Disclosures has recommended that banks, insurance companies, and asset managers disclose the potential impacts of climate-related risks to their operations, strategy, and financial planning).

[3] For a larger sample of existing and proposed non-pricing policies in Canada, see Appendix A.

[4] Policy initiatives such as output-based allocations (OBAs), which recycle carbon pricing revenues toward firms that are emissions intensive and trade exposed to avoid emissions leakage, can also be an important type of subsidy policy (Fischer & Fox, 2007). However, because they can be considered part of the design of a carbon pricing scheme (rather than being an entirely separate policy), OBAs are outside the scope of this report. For more on OBAs, see our report on revenue recycling, *Choose Wisely* (Canada's Ecofiscal Commission, 2016a).

2.2 OVERALL OBJECTIVES FOR POLICY

What are sensible objectives for these types of policies? And how should we assess their potential contribution to a broader package of GHG policies? In a previous analysis from the Ecofiscal Commission, two overarching objectives led us to recommend carbon pricing as the way forward for Canada: effectiveness and cost-effectiveness (Canada's Ecofiscal Commission, 2015). These objectives are equally important for non-pricing climate policies.

Policies should be *effective* at reducing GHG emissions

The effectiveness of a policy is the extent to which it can reduce GHG emissions. A policy's effectiveness can have a time dimension; it might deliver a one-time amount of emissions reductions, a relatively constant annual level of reductions, or reductions that increase or decrease over time.

Reducing GHG emissions in Canada will contribute toward international efforts to limit the effects of climate change. Yet, under current policies, Canada is likely to face a sizable gap between its emissions trajectory and its existing 2030 targets (Jaccard et al., 2016; Sawyer & Bataille, 2016). Well-chosen and well-designed complementary policies can help Canada to close its emissions gap. These policies can also have an impact on emissions beyond Canada's borders, as discussed in Box 2.

Box 2: Pursuing GHG mitigation beyond Canada's borders

This report is primarily concerned with policies designed to reduce GHG emissions within Canada, thus contributing toward the achievement of provincial and national targets. Yet climate change is a global issue, and the effects of Canadian policies on global emissions should not be ignored.

On one hand, policymakers should consider how domestic policies might cause increases in foreign emissions. This effect is known as *leakage*: If Canadian policies cause domestic economic activity—along with the associated emissions—to move to jurisdictions with weaker policy, the net result is local economic costs without any associated global environmental benefits. As we discuss in *Choose Wisely*, effective climate policy should seek to avoid leakage through smart design (Canada's Ecofiscal Commission, 2016a).

On the other hand, domestic policies can sometimes contribute to emissions reductions outside of Canada. If Canadian policies lead to technological innovations that can reduce more emissions at lower cost, these technologies can be exported and used to enable emissions reductions elsewhere. Policies might even actively seek to drive international emissions reductions. Clean procurement policies, for example, could restrict government purchases to low-carbon products, even when the supply chains from those products (and thus the life-cycle emissions associated with them) extended into other countries. This would lower emissions both domestically and internationally.

Policies should minimize the cost of emissions reductions

The cost-effectiveness of a specific policy is the extent to which it reduces GHG emissions at a lower cost than other policies. Costs of policy might be private (i.e., experienced by households and businesses directly) or public (i.e., borne by society as a whole).

Meeting Canada's 2030 emissions target will be a considerable challenge, and ensuring the country does so at the lowest possible cost is important. Policies with higher-than-necessary costs weaken economic growth, which translates into lower income and well-being for ordinary Canadians. High costs also undermine the political durability of environmental policy: when policies have limited economic credibility, they are more likely to be terminated by future governments. As we will see, however, assessing cost-effectiveness can be challenging. Some policies might have higher upfront costs but help avoid "locking in" certain types of emissions, and thereby *reduce* mitigation costs over the long term. This can be especially important when considering long-lived assets such as buildings and infrastructure.

As we showed in *The Way Forward*, economy-wide carbon pricing is cost-effective. Yet, as we will show in this report, other policies can contribute toward cost-effective emissions reductions, especially when those policies can enhance the operation of the carbon price. Well-designed packages of policies can help deliver emissions reductions at a lower overall cost than carbon pricing alone. But poorly chosen or badly designed policies, by increasing overall costs, can undermine carbon pricing.

Policies can be evaluated on other objectives, too

Good policy goes beyond effectiveness and cost-effectiveness; other objectives are also important, such as a policy's fairness. One aspect of fairness relates to whether policies disproportionately affect low-income households. Consider, for example, a policy that requires energy efficiency retrofits in homes in the context of other policies seeking to provide affordable, subsidized housing. If the cost of these retrofits is borne by the occupants of social housing, the retrofit policy may undermine the goal of providing affordable housing. (This could be addressed with an additional, offsetting policy that would compensate the social housing residents or cover their costs.) These other potential outcomes need to be considered.

Objectives can also be specific. For example, improved urban mobility helps cities function more efficiently, and can be an important policy objective on its own. To the extent that a climate policy has implications for the variety and quality of transportation options in a city, it could be evaluated against objectives of improved urban mobility.

Considering how the impacts of a policy are distributed—across households, sectors, or regions—can also be important, since in some cases these impacts might require offsetting policy responses. This is especially true in cases where there are implications around fairness, competitiveness, or political acceptability.

In this report, we focus mainly on the two primary objectives of effectiveness and cost-effectiveness, though we also address additional considerations in specific cases.

2.3 GOALS OF THIS REPORT

This paper addresses four related but distinct challenges. Different jurisdictions—with varying degrees of progress toward implementing carbon pricing and other policies—will have different priorities within these four challenges.

First, governments with existing or proposed carbon pricing policies require an approach to **evaluating non-pricing climate policies**. Not all additional policies are necessarily *complementary* to carbon pricing. This may be particularly true for policies implemented prior to carbon pricing, whose genuine complementarity may never have been evaluated, or even considered.

Second, policymakers looking to implement a coherent package of climate policies require a process for **identifying policies** that will appropriately complement carbon pricing. What types of policies are required for an effective and cost-effective package?

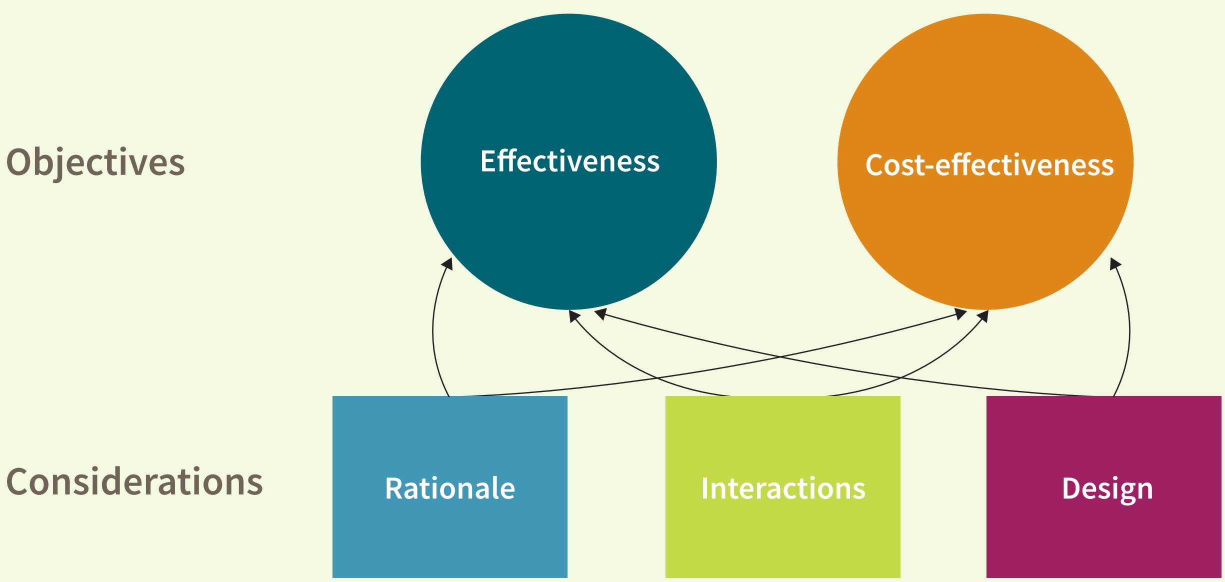
Third, policies need to be **designed** to ensure they are indeed effective and cost-effective. As we will see in Section 3, even if a policy can, in principle, complement carbon pricing, it will not improve the performance of a policy package unless it is well designed.

Fourth, it is important to **implement a coherent package of climate policies** that drives sufficient emissions reductions while minimizing costs. This package must account for all the issues embodied in the first three challenges, but also for the various and complex interactions *between* policies.

3 CONSIDERATIONS FOR COMPLEMENTARY POLICIES

The objectives of policies intended to support carbon pricing are clear: improving effectiveness, cost-effectiveness, or both. But *how* can policymakers identify policies that achieve these objectives? This section explores three key considerations that affect policy performance, as summarized in Figure 1.

Figure 1: Objectives and considerations for complementary climate policies



The *rationale* for a policy, how it *interacts* with carbon pricing, and the *design features* of the policy can each have implications for both the extent to which the policy reduces GHG emissions and the costs at which it does so.

We first consider the **rationale** for an additional GHG policy. The rationale is the reason *why* the policy is needed in addition to carbon pricing. We outline three possible rationales for a complementary policy: 1) it targets emissions in parts of the economy that carbon pricing does not address; 2) it enhances the operation of the carbon price; or 3) it offers "co-benefits" distinct from reductions in GHG emissions. As we discuss, policies lacking one of these rationales will be ineffective, relatively costly, or both.

Second, we consider the implications of **interactions** between the additional policy and the carbon price. A policy will generally interact with a carbon tax and a cap-and-trade system in different ways, and we discuss the implications of each for the policy's effectiveness and cost-effectiveness. In addition, we discuss the implications of an additional policy's interactions with other non-pricing policies.

Third, we consider the impact of a policy's **design** on its effectiveness and cost-effectiveness. In particular, we discuss five key design elements: stringency, coverage, flexibility, predictability, and governance. As we will see, there are often important trade-offs across these five elements.

3.1 RATIONALES FOR ADDITIONAL, NON-PRICING POLICIES

A policy can usefully complement a carbon price in three ways:

1. **Gap-filling** policies apply to GHG emissions not covered by the carbon price.
2. **Signal-boosting** policies address market problems to make carbon pricing work better.
3. **Benefit-expanding** policies achieve both GHG mitigation and other objectives.

Policies that fill none of these roles will not improve the performance of carbon pricing. In fact, they risk increasing the overall costs of climate policy (Antonioli et al., 2014; Levinson, 2010; OECD & World Bank, 2015).[5] If genuine complementary policies are unavailable for some reason, and more emissions reductions are nonetheless required, the cost-effective policy approach is to increase the carbon price.

Complementary policies can fill gaps in climate policy coverage

Broader policy coverage leads to lower costs. This is a core principle for carbon pricing (Canada's Ecofiscal Commission, 2015). Applying a consistent financial incentive to the largest share of emissions possible ensures that more low-cost abatement options are realized (OECD & World Bank, 2015; Sijm, 2005; Wilkins, 2008).

Yet some GHG emissions do not lend themselves so easily to carbon pricing. Some emissions can be difficult to measure, or the high costs of measuring them might make the exercise prohibitive. Table 2 outlines key sources of GHG emissions that are typically left uncovered by carbon pricing. Such emissions can be addressed by well-chosen and well-designed "gap-filling" policies.

[5] Some have argued that political considerations could justify higher costs in the short term (e.g., Haley, 2016; Meckling et al., 2015). Certain policies, particularly subsidies, can create clear benefits for specific sectors or the developers of specific technologies. By doing so, they can help build political coalitions that can then be mobilized to push for more ambitious climate action. This is an important feature, since "smart policy aims not just to reduce carbon but to build constituencies for future policy" (Haley, 2016). But these policies can be a double-edged sword. When beneficiaries of non-pricing policies become vocal and influential interest groups, they are likely to push for the continuation of policies that are ineffective or overly costly. Such "rent seeking" behaviour can generate significant overall costs for society (Murphy et al., 1993).

Table 2: Common policy "gaps" with carbon pricing

Sector/ Type	Estimated 2014 GHG Emissions in Canada (% of total CO_2e)[6]	Sources of Emissions	Challenges With Carbon Pricing	Examples of Gap-Filling Policies
Agriculture	73 Mt CO_2e (10%)	Fertilizers, livestock, soils	• Emissions come from many diffuse sources and are not easily measured • They can vary widely across sources depending on management practices and local conditions	• Regulations or incentives on land management practices • Payments for ecosystem goods and services (e.g., paying farmers to retire marginal agricultural land)
Waste	28 Mt CO_2e (4%)	Municipal solid waste sites and wood waste sites	• Emissions from waste sites are difficult to measure • They vary widely across sites owing to different mixes of waste materials and local waste collection practices	• Offset markets for GHG reductions from waste sites • Banning organics in landfills (City of Vancouver, 2017; Government of Nova Scotia, 2014)
Fugitive emissions	60 Mt CO_2e (8%)	Flaring, leaks, venting, accidental releases	• Emissions are difficult to detect and measure, and estimates can vary widely • They can also be unpredictable when caused by mechanical failure	• Leak detection and repair requirements • Offset markets for demonstrable emissions reductions
Process emissions	51 Mt CO_2e (7%)	Non-combustion emissions from industrial processes	• Emissions can vary widely owing to complex and varied industrial processes • They can be diffuse and difficult or costly to measure	• Regulating small industrial emitters' process emissions where they are not covered by carbon pricing (large emitters would likely be covered more cost-effectively by carbon pricing)
Land use, land-use change and forestry	72 Mt CO_2e (10%)[7]	Emissions flux between the atmosphere and Canadian forests, wetlands, and croplands	• Emissions vary year to year and are unpredictable given wildfires, pest infestations, controlled burning, etc. • Emissions are diffuse and often remote, making them difficult or impossible to measure • Emissions from the sector can span several years or decades	• Regulations on forest management practices • Fire/pest prevention measures • Offset markets to encourage conservation • Policies that increase use of durable wood products that sequester carbon (Government of Canada, 2016a)

Note that summing coverage gaps can be misleading. Some sectors, such as land use, land use change and forestry may have net emissions in one year, and net sequestration the next. Other gaps might reflect narrower carbon pricing coverage. For example, some process emissions could be directly covered by carbon pricing. And sectors such as waste could be indirectly included using offsets.

Leaving the emissions described in Table 2 beyond the reach of climate policy would mean that some low-cost mitigation opportunities would likely go unrealized. More of the needed reductions would then have to come from the portion of the economy covered by carbon pricing, which would only occur with a higher carbon price. Using additional, non-pricing policies to reduce emissions in parts of the economy untouched by carbon pricing can therefore drive more emissions reductions at a lower overall cost (OECD & World Bank, 2015; Wilkins, 2008). Box 3 discusses natural sequestration—a potentially important source of emissions reductions not easily achieved with a carbon price. It describes Canadian examples of policies to enhance natural sequestration.

[6] Different types of GHGs have different atmospheric lifespans and different global warming potentials (GWP). CO_2 equivalents (CO_2e) express the GWP of different GHGs as if an equivalent amount of CO_2 had been emitted. For example, one tonne of methane—a common type of GHG emission in the agriculture sector—has 25 times the GWP of CO_2 over a 100-year time horizon. One tonne of methane would therefore be expressed as 25 tonnes of CO_2e (ECCC, 2015).

[7] Emissions from land use, land-use change and forestry (LULUCF) can vary widely from year to year, depending on natural disturbances (e.g., wildfires, drought). For example, while net emissions in 2014 were estimated at 72 Mt, for 2013, a net GHG *reduction* of 30 Mt was estimated (Government of Canada, 2016d). Canada includes these emissions as part of its GHG Inventory, but they are not currently included in emissions forecast scenarios. The Government of Canada has signalled in its Nationally Determined Contribution to the UNFCCC its intent to include mitigation from the LULUCF sector as part of future reporting (Government of Canada, 2015).

Box 3: Enhancing natural sequestration as a gap-filling climate policy

Natural sequestration refers to the ability of natural formations and systems to absorb, capture, or sequester carbon as part of the carbon cycle. Systems capable of sequestering carbon include soil, plants, large bodies of water, and peatlands (Dean & Gorham, 1998; Peichl et al., 2006; Post & Kwon, 2000).

Careful land-use planning can prevent the degradation of natural systems, or even enhance their ability to sequester carbon. But natural carbon sinks are dynamic systems with inflows and outflows of carbon from non-point sources that are difficult to measure, and therefore difficult to price (Bellassen & Luyssaert, 2014; Sommer & Bossio, 2014). As a result, gap-filling policies may be required to mandate or incentivize practices that can enhance natural sequestration.

The Pan-Canadian Framework on Clean Growth and Climate Change states that federal, provincial, and territorial governments will seek to enhance natural carbon sequestration by using land-use and conservation measures that protect and enhance natural carbon sinks—including forests, wetlands, and agricultural lands (Government of Canada, 2016a).

The specific actions taken to enhance natural sequestration tend to be unique to a jurisdiction's natural landscape and economy. British Columbia's Climate Leadership Plan focuses on the province's forests, laying out actions to enhance their carbon storage potential, including increasing replanting and fibre recovery rates in areas affected by the mountain pine beetle (Government of British Columbia, 2016a).*

In Ontario, the province's Climate Action Plan includes several initiatives for improving natural sequestration, including developing a strategy to maximize long-term carbon storage in agricultural soils, increasing tree planting, expanding the Greenbelt, developing a stewardship initiative for the province's grasslands, and improving monitoring of natural carbon storage systems (Government of Ontario, 2016).

These kinds of actions help to achieve mitigation opportunities in addition to those associated with reducing the combustion of fossil fuels. Assuming they are cost-effective, they can fill an important policy gap in jurisdictions with a carbon price.

* *While they may lead to mitigation in the short term, the additionality and lasting benefits of reforestation policies have been questioned. If the forests are eventually logged and residual fibres burned, for instance, then there is no long-term sequestration (Bennett, 2016).*

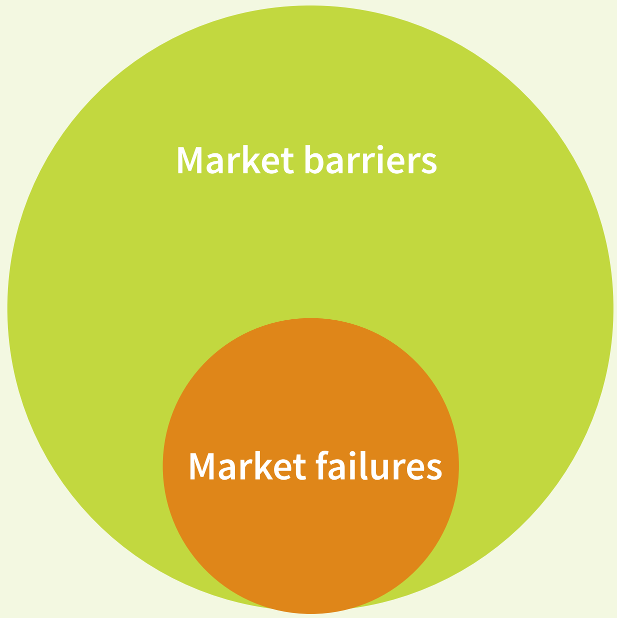
Complementary policies can boost the carbon price's signal

A carbon price works by relying on markets—not governments—to decide where and how GHG mitigation occurs. A price signal creates incentives for emitters to reduce their emissions, and drives cost-effective changes in the behaviour of firms and households. However, carbon pricing does not always work as well as it could, because specific features of the market weaken the price signal. In particular, problems known to economists as "market failures" can get in the way (Bennear & Stavins, 2007; Jaffe et al., 2005).

Market failures are circumstances where the free market, left to its own devices, generates an economically inefficient outcome. When significant, such market failures justify policy intervention designed to improve economic efficiency (Jaffe & Stavins, 1994). Table 3 provides examples of these situations (and others) as well as the kinds of policies that can address them.

As illustrated in Figure 2, we distinguish market failures from a wider set of market *barriers*—features of a market that do not create inefficiency but nonetheless limit the uptake of seemingly cost-effective actions. Market barriers may simply reflect underlying preferences or costs. For example, businesses might be risk averse

Figure 2: A Venn diagram of market barriers and failures



Market *barriers* limit the impact of carbon pricing. Some, but not all, market *barriers* are market *failures*. Low-cost policies that overcome market failures have the potential to be efficiency-enhancing for the economy overall.

and thus reluctant to adopt untested technologies, or consumers with "range anxiety" might be reluctant to purchase electric vehicles that they cannot easily and conveniently charge. Since market barriers may represent such underlying costs or preferences, there is no clear efficiency basis for policy intervention. In what follows, we focus on the improvement of efficiency with signal-boosting policies designed to address genuine market failures.

It is worth recalling that a crucial market failure is the underlying justification for using a carbon price to reduce GHG emissions. Emitters of GHGs do not bear the full cost of their actions; these are external costs. A carbon price addresses this negative externality by requiring emitters to bear the full cost of their polluting actions, thereby inducing them to reduce their emissions. When *additional* market failures are at play, however, the signal from carbon pricing can be weakened, and its overall performance reduced (Levinson, 2010; OECD, 2011a; Sorrell & Sijm, 2003). Table 3 provides examples of market failures that reduce the economic signal produced by a carbon price. The table also provides examples of "signal-boosting" policies that, if well designed, could complement and enhance a carbon price. The examples in the table are not exhaustive—other types of market failures could also call for signal-boosting policies.

Table 3: Market failures that justify signal-boosting policies

Failure type	Description	Relation to Carbon Pricing	Examples of Signal-Boosting Policies	How the Signal Is Boosted
Incomplete information	• Information failures can occur when individuals or firms do not have the information necessary to make informed choices • They may be the result of information asymmetries between buyers and sellers	• Carbon pricing works best if emitters make decisions with all necessary information • In some cases, however, they might not have access to critical information about the emissions intensity and costs of alternative products and technologies (Fischer & Preonas, 2010)	• Mandatory energy efficiency testing and auditing (e.g., Ontario's planned energy efficiency audits for buildings) (Government of Ontario, 2016) can increase the demand for homes and buildings that are less emissions intensive	• An energy-efficient home might be more expensive at the point of purchase or construction, but save costs over its lifetime • If consumers know how energy intensive a home is and what the carbon price will be, trade-offs between upfront and lifetime costs will be clear, and the value of energy efficiency will be better reflected in home prices • Acquiring this information can be too expensive for an individual, but government can exploit economies of scale to make it less costly
Network externalities	• Network externalities occur when benefits to an individual depend on how many others are also using the product in question • Individual emitters do not have the incentive to take the actions that would generate these benefits	• In response to a carbon price, households and businesses will seek to use low-carbon alternatives to reduce their emissions • However, they might be discouraged when a given alternative is not yet used or deployed on a wide enough scale (e.g., electric vehicles)	• Policies that encourage network development or densification can induce individuals to adopt a product (e.g., electric vehicles) • For example, the City of Vancouver mandates that all new multi-unit family dwellings must have at least 20% of parking spaces equipped with electric charging stations	• Consumers may recognize that electric vehicles will save them money as carbon prices rise, but be reluctant to buy them if they think charging will be difficult or inconvenient • By putting charging stations in parking lots for multi-family dwellings, consumers who live there are assured they can conveniently charge their car at home, and owning an electric vehicle begins to look more attractive
Split incentives	• "Split incentives" refer to situations where the economic interests of the owner differ from the interests of the user in such a way that an efficient outcome is not achieved • This type of failure is also known as a principal–agent problem	• In the buildings sector, tenants may pay the electricity and heating bills, but because they do not own the building, they may have a limited incentive to do energy efficiency retrofits that pay off over the long term (City of Vancouver, 2012) • If the tenants will be the ones who reap the benefits, then the building owners may not have sufficient incentive to invest in retrofits either	• Policies to bolster the incentives that tenants or landlords face for energy efficiency retrofits can address this problem • For example, the Quebec government offers financial assistance to residential building owners to purchase energy-efficient windows (NRCan, 2016b)	• Landlords know that renters will be looking for energy-efficient homes that are less expensive to heat under the province's carbon pricing system • The smaller the upfront investment cost, the more likely retrofits are to pay off in the form of new tenants who are willing to pay higher rent in exchange for greater energy efficiency • By helping reduce the cost that landlords pay for energy efficiency retrofits, the government makes these investments more attractive to landlords, and helps unlock cost-effective GHG mitigation

Table 3: Market failures that justify signal-boosting policies (continued)

Failure type	Description	Relation to Carbon Pricing	Examples of Signal-Boosting Policies	How the Signal Is Boosted
Knowledge spillovers	• Society typically benefits when innovations are used and dispersed—when knowledge "spills over" to those who did not produce it • However, companies might under-invest in costly innovation if the benefits will be shared by others	• A carbon price incentivizes the development and deployment of low-carbon technologies • In practice, however, the market signal from carbon pricing may not be enough to encourage the socially optimal level of R&D (Fischer & Newell, 2008; Kalkuhl et al., 2013)[8]	• Public investment in R&D, and regulations and subsidies that stimulate public and private sector innovation can help to unlock low-cost mitigation options • For example, the Tech Fund of Sustainable Development Technology Canada (SDTC) supports the development and pre-commercial demonstration of clean-tech solutions	• By funding demonstration of technologies, SDTC helps to signal to other market actors that the technology is not as unproven as they may think, encouraging entry • This helps bridge the gap between how much investment in the technology is warranted and how much the private sector is willing to provide • As investment in the technology rises, the cost of GHG mitigation is reduced • These spillovers may have an international dimension, lowering emissions in Canada and abroad
Uncertain future carbon prices	• When households and firms are unsure about future carbon prices, they may be reluctant to make investments in low-carbon alternatives • This uncertainty can stem from either a lack of clear policy on longer-term carbon prices or a belief that a stated price trajectory could change with a change in government[9]	• This type of failure relates to the predictability and/or durability of carbon pricing itself; it could be considered a special case of "incomplete information," as described in the first row of this table • If households and firms do not know what future prices will be, this can limit their willingness to make cost-effective investment decisions, especially in cases where an investment is expected to be long-lived (e.g., buildings) (Nelson et al., 2010)	• In Canada, the federal government has announced that carbon prices will be rising to $50/tonne by 2022, with a policy review planned before any further price trajectory will be announced • To address the uncertainty of future carbon prices, the government is planning a nationwide clean fuels standard (Government of Canada, 2016a)	• Developing the technological ability and industrial capacity to lower the emissions intensity of fuels is a costly undertaking • A high and rising carbon price would signal to the market that such investments will be rewarded; however, so long as post-2022 carbon prices are unclear, the market may under-invest in what is perceived to be a risky investment • In the absence of a long-term carbon price signal, regulations or subsidies may substitute for one • By creating a technology-flexible, life cycle-focused fuel standard, the federal government is helping to overcome the failure of (uncertain) carbon prices to bring about a timely transition in the fuels sector

8 R&D and learning-by-doing issues are common market failures that are not specific to low-carbon technologies (Gillingham & Sweeney, 2010). Similarly, the clean-tech sector often suffers from a lack of scale-up financing, a market failure that may require policy intervention but is not unique to the sector (Moffatt, 2016).

9 Institutions and processes that aim to depoliticize climate policy can help limit carbon price uncertainty. By creating arm's-length regulatory bodies and by instituting carbon budget planning processes, the uncertainty stemming from political risks can be mitigated (OECD, 2014).

Table 3: Market failures that justify signal-boosting policies (continued)

Failure type	Description	Relation to Carbon Pricing	Examples of Signal-Boosting Policies	How the Signal Is Boosted
Public infrastructure	• Public infrastructure includes buildings, transportation networks, electrical grids, sewerage, etc. • It is typically provided directly by the public sector or through a publicly owned or regulated utility	• Carbon pricing provides incentives to adopt low-carbon alternatives • However, public infrastructure can obstruct their adoption when the necessary supporting infrastructure is not available • Or, where there is a bias toward traditional infrastructure, incentives can tilt toward carbon-intensive options	• The intermittency of renewable energy can make it challenging to deploy on a large scale, especially in cases where a jurisdiction self-supplies all of its electricity • By building transmission infrastructure that links jurisdictions (Government of Canada, 2016a), the problem of intermittency can be addressed by reducing the differences between supply and demand	• A publicly managed electric utility may wish to respond to carbon pricing by constructing more renewable generation capacity, but be reluctant to do so, given its intermittency • If the jurisdiction is connected to other electricity markets, it can be more confident that any supply shortfalls can be met by purchasing power from other markets, and will be more likely to build renewable generation capacity • To the extent that the other markets have differing generation sources, demand peaks, and intermittency drivers, it can also expect to procure this needed supply—and to sell its own excess supply—at reasonable prices
Policy coordination problems	• Policy coordination problems may relate to other government policies that are undermining or obstructing carbon pricing (e.g., fossil fuel subsidies) (OECD, 2011b) • Or, they may stem from the indispensability of government policymaking in a particular sphere (e.g., zoning decisions, budgeting processes)	• If other government policies weaken carbon pricing's signal, it can cause firms and households to make inefficient investment decisions, and tilt the playing field away from low-carbon alternatives • Alternatively, if zoning policies do not lend themselves to low-carbon development, or if government budgets do not give departments enough fiscal capacity to respond to carbon pricing, otherwise cost-effective mitigation can be blocked	• Canadian policies include many tax-based measures aimed at the oil and gas sector, the scope and extent of which are subject to vigorous debate (Sawyer & Stiebert, 2010) • To the extent that these policies support the production or consumption of fossil fuels, they undermine the price signal created by carbon pricing • To address this, the federal government has pledged to phase out inefficient fossil fuel subsidies by 2025, in concert with its G20 partners (Government of Canada, 2016a)[10]	• When fossil fuels extraction is subsidized, its cost of production is artificially lowered • As a result, the cost to consumers is artificially lowered as well, even when a carbon price policy is layered on top; this points to an institutional coordination problem where one government department is pricing emissions while another is indirectly subsidizing them • When fossil fuel subsidies are phased out, the price that consumers pay (which includes the carbon price) more closely approximates the true social cost of their consumption • As a result, consumers adjust their consumption accordingly and become more likely to make investments that will limit their fossil fuel consumption (e.g., by installing an electric furnace instead of one using natural gas or fuel oil)

[10] If fossil fuel subsidies in other jurisdictions were to remain in place while Canada phased out its own, then this would have leakage implications; for more on minimizing leakage, see *Choose Wisely* (Canada's Ecofiscal Commission, 2016a).

Specific market failures vary by sector and call for different types of policy responses. Box 4 discusses the buildings sector and the potential need for signal-boosting policy to support "net zero" homes. It presents some policy responses currently being proposed in various Canadian jurisdictions.

Box 4: Boosting the carbon pricing signal with policy on net-zero homes

Net-zero emissions buildings are emissions-neutral, self-reliant systems with a zero annual energy-use balance (Sartori et al., 2012). They use best-practice energy-efficiency strategies, such as high-efficiency insulation, airtightness, window glazing, energy-efficient appliances, and "passive" methods such as orientation and shading (Li et al., 2013).

These buildings also meet their own energy demands through local zero-emissions sources or on-site renewable energy systems (Canada Mortgage and Housing Corporation, 2016; Torcellini et al., 2006).

Buildings account for 10.5% of Canada's national GHG emissions (Government of Canada, 2016d). Increasing the construction of net-zero homes will help to reduce the sector's emissions, and Canadian developers are already beginning to make net-zero homes commercially available. Despite the availability of these technologies and the incentive for their adoption provided by carbon pricing (in the parts of the country where carbon is currently priced), their adoption has been slow. Only small numbers of net-zero homes have been constructed in Ontario, Quebec, Alberta, and Nova Scotia over the last few years (Mays, 2016).

One can argue that this slow rate of adoption is due to specific market failures. On the demand side, incomplete information may leave consumers unaware of the return on investment; net-zero homes can increase construction costs by 15% to 20%, but provide a favourable return on investment over their lifetimes (Adhikari et al., 2012; NRCan, 2017; Tsalikis & Martinopoulos, 2015; Tse & Fung, 2007). On the supply side, issues with network externalities and knowledge spillovers, including builders' lack of expertise with net-zero homes, may be inhibiting their uptake of available building methods and technologies (Klemick & Wolverton, 2013). The overall result is too little demand combined with too little supply, and thus a very small market.

Policies that encourage the adoption of net-zero homes could help to overcome these market failures. Instituting policy that mandates or incentivizes net-zero homes will help make buyers more familiar with them and their merits, and as builders gain more experience with them and demand for them grows, their costs can be expected to decrease.

Several jurisdictions in Canada are implementing policy on net-zero homes. In July 2016, Vancouver announced plans to achieve zero emissions in all new buildings by 2030, and reduce emissions from newly constructed buildings by 90% by 2025 (City of Vancouver, 2016). It is the first city in Canada to introduce requirements for net-zero buildings. The Ontario government has included several policies for net-zero homes in its 2016 Climate Change Action Plan, including a rebate program for individuals who purchase or build net-zero homes, updates to the Building Code by 2020, and longer-term energy-efficiency targets for small net-zero buildings by 2030 (Government of Ontario, 2016).

Such actions can reinforce the incentive that carbon pricing provides to adopt net-zero technologies, and help to overcome market failures impeding their adoption. However, as we see below, the mere existence of a market failure is not a sufficient justification for any policy intervention. Smart signal-boosting policies should be both effective and cost-effective.

Identifying market failures that might be weakening the carbon price signal is a critical task. But policymakers must be cautious. When mitigation opportunities go unrealized, it does not necessarily imply that there is a market failure that must be corrected by policy. Price-inelastic demand for a high-emissions good provides a notable example: When buyers or sellers are unresponsive to increases in the good's selling price, it does not necessarily signal that there is a market failure at play. Instead, there may be good reasons why they continue to prefer to use the product. Forcing an unwanted choice on them could risk creating outcomes that are *even less* efficient. For example, as Parry and Small (2015) note: "The observed reluctance of consumers to pay for vehicles with higher fuel economy may reflect their awareness of possible undesirable side effects, such as reduced acceleration or greater likelihood of needing repairs. Such 'hidden costs,' if real, would then create an additional cost of a policy mandating high fuel economy." Policymakers should be sure that they are dealing with genuine market *failures*, and not merely market barriers that reflect genuine costs.

Similarly, the real-world cost of designing and implementing policies further complicates this story. Even where a legitimate market failure might exist, a corresponding policy intervention can have costs that exceed benefits. A case can be made, for example, that electric vehicle (EV) markets are subject to failures such as incomplete information, network externalities, and knowledge spillovers. British Columbia, Ontario, and Quebec all offer subsidies toward the purchase of EVs, perhaps as a response to these potential market failures. Yet despite the benefits they may create, subsidies toward the purchase of EVs tend to be very costly and may not be an optimal response to market failures in the EV sector. Several other policy interventions are possible (e.g., public information campaigns, building EV charging infrastructure, funding R&D on EV technology). The mere existence of market failures in the EV sector is not enough to justify EV subsidies; rather, a case needs to be made for why subsidies are the best response to these market failures. We return in Section 5 to EV subsidies as a detailed case study of signal-boosting policy.

Complementary policies can have non-GHG co-benefits

Ideally, GHG mitigation would be pursued with climate-focused policies, while other objectives would be pursued with other policies designed specifically for the task. But there will inevitably be policies that offer both GHG mitigation and other benefits at the same time (Wilkins, 2008). In some cases, mitigation may be the primary goal of the policy, and in others it may be only a beneficial by-product of a policy primarily focused on other objectives. A policy that delivers GHG reductions and accomplishes other policy goals can complement a carbon price by achieving outcomes that a carbon price alone cannot. If they are done right, these policies may be economically sensible: greater overall costs might be more than offset by greater social benefits.

An example of a co-benefit policy is financial support for public transit infrastructure, a policy that figures prominently in the Pan-Canadian Framework (Government of Canada, 2016a). Improved transit networks can support urban mobility and reduce costly traffic congestion—important goals in themselves—but by allowing residents to rely less on private vehicles for transport, the policy will also likely reduce GHG emissions. Another example is the co-benefits that investment in cycling infrastructure can generate (see Box 5).

Box 5: Investments in cycling infrastructure as a benefit-expanding policy

Not all policies need to have GHG mitigation as their primary objective to be considered a benefit-expanding complementary policy. Building urban cycling infrastructure, for example, is a type of policy that is pursued by many cities, because it has several benefits unrelated to climate change.

In particular, improving cycling infrastructure can improve health, fitness, and safety for cyclists, reduce transportation costs for people who cycle instead of drive, reduce the costs associated with traffic congestion, and increase the overall efficiency of the transportation network (Litman, 2017).

In addition to these more prominent benefits, cycling infrastructure can also, as a secondary benefit, reduce GHG emissions. Depending on its design, cycling infrastructure can encourage some drivers to opt for cycling instead of driving. In these cases, total GHG emissions associated with transportation can decrease.

When considered in isolation, the GHG mitigation benefits from cycling infrastructure are unlikely to lead to cost-effective climate policy. In its 2016 Climate Action Plan, for example, the Ontario government estimated that the cost of its investments in cycling infrastructure would translate into approximately $500 per tonne of GHGs reduced (Government of Ontario, 2016). However, the overall cost-effectiveness of cycling infrastructure improves markedly when the other health, environmental, and economic benefits of cycling are considered.

While the co-benefits of cycling infrastructure are no doubt real, they can be difficult to quantify. Therefore, when discussing the net costs of investing in cycling infrastructure, it is important to acknowledge the uncertainty surrounding quantitative estimates.

Table 4 provides a sample of policies that might generate both GHG and non-GHG co-benefits. The non-GHG policy objectives shown in the table are intended only to be illustrative—it is ultimately up to governments and citizens to define, articulate, and defend their goals for public policy (Wilkins, 2008).

Of course, the simple fact that a given policy may offer both GHG benefits and non-GHG co-benefits does not necessarily justify implementing the policy. As discussed below, there are additional factors to consider. However, because they form such an important part of understanding a policy's performance, any non-GHG benefits must also be considered when assessing the merits of any given policy. To do so, a policy's objectives—both GHG and non-GHG—must be clearly defined, an important best practice in climate policy (Calder, 2015). We return to this issue in Section 4.

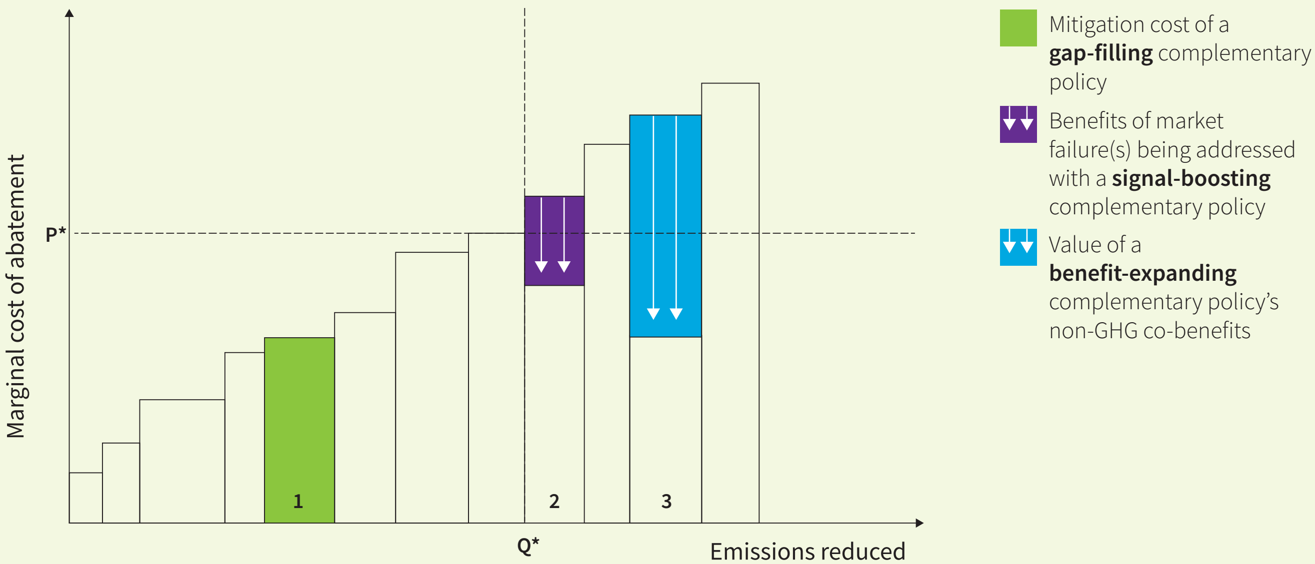
Table 4: Policies that offer both GHG reductions and non-GHG co-benefits

Policy Area	Connection to GHG Emissions	Examples of Policies With Non-GHG Co-Benefits
Non-GHG environmental issues	• Environmental challenges such as air pollution, water pollution, soil erosion, biodiversity loss, and others impose costs on society • Climate policies that reduce these sources of environmental damage can generate broader social benefits while also delivering GHG mitigation (Gale et al., 2015)	• Ontario's phase-out of coal-fired electricity is estimated to have reduced air pollution, in addition to reducing GHG emissions (Harris et al., 2015) • Reduced air pollution means reduced impacts on human health and reduced health-care expenditures
Infrastructure development	• Infrastructure supports productivity improvements and enables movement of products and labour throughout the economy • Specific infrastructure investments can deliver GHG reductions by supporting low-carbon energy and transportation • This is especially true when considering the long lifespan, or "lock-in," of infrastructure (Centre for Spatial Economics, 2015)	• A planned light-rail transit network in Surrey, B.C., is expected to reduce congestion and improve personal mobility, while also reducing GHG emissions (TransLink et al., 2012) • Canada's Infrastructure Plan provides funding for Phase 2 of Ottawa's planned light-rail system. The project is expected to reduce car travel, improve urban mobility, and reduce GHG emissions and urban pollution (Department of Finance, 2016)
Climate change adaptation and risk reduction	• Some climate policies primarily designed to reduce GHG emissions may also help prepare for the risks or adapt to the effects of climate change • Similarly, policies primarily designed as adaptation measures may also help mitigate GHGs (Lobell et al., 2013)	• Drought mitigation measures can enable climate change adaptation by reducing climate-driven risks to agriculture and urban water supplies • At the same time, they can help avoid GHG emissions by limiting the risk of forests dying off and releasing their stored carbon
Liveable communities and quality of life	• Zoning and land-use policies that encourage high-density development might be focused on both GHG mitigation and improving the "liveability" of communities • Liveability and quality of life are subjective, but such objectives may still call for policies that can both deliver on them and reduce GHGs at the same time	• Increasing the amount of green space can make a community a more attractive place to live and can also increase natural GHG sequestration • To improve urban air quality, some global cities are beginning to ban diesel cars, which will also reduce GHG emissions (Condliffe, 2016)
Long-term industrial planning	• Policymakers may deem it desirable to encourage the development of an existing or potential clean-tech industry • Policies focused on expanding this sector may also help Canada to achieve its GHG emissions targets	• Significant investments have been made to develop tidal energy in Nova Scotia • If successful, the technology could help to displace coal-fired electricity in the province and reduce GHG emissions, as well as offer opportunities for export (Gardner Pinfold Consultants Inc., 2015)
Addressing leakage and competitiveness	• Competitiveness disadvantages from carbon pricing can create the risk of high-emitting firms simply relocating to other jurisdictions • This can lead to leakage, where GHG emissions shift across jurisdictional boundaries • By preventing leakage, competitiveness-focused policies can also contribute to GHG mitigation	• Border carbon adjustments protect competitiveness by adjusting the price of imports and exports to account for other jurisdictions' carbon prices (Dissou & Eyland, 2011) • Such policies help protect domestic firms' competitiveness and, by avoiding leakage, help reduce GHGs

Each type of complementarity can have different implications for effectiveness and cost-effectiveness

The three types of complementarity that we have discussed can help make climate policy more effective or cost-effective, but for different reasons. Figure 3 uses a stylized marginal abatement cost curve to show the differing implications that various types of complementary policies can have for the effectiveness and cost-effectiveness of GHG mitigation.[11]

Figure 3: Complementary policies and the marginal abatement cost curve



The figure shows a stylized *marginal abatement* cost curve. It shows a range of mitigation actions, each represented by a single bar. The width of a given bar shows the amount of potential mitigation that an action represents, while its height shows the cost of that abatement, per tonne of CO_2e. P* is the level of the carbon price in the jurisdiction (either a carbon tax or the price of allowances under a cap-and-trade system), while Q* represents the total amount of GHG mitigation that occurs when that carbon price is in place. Numbered bars 1, 2, and 3, respectively, represent mitigation actions that result from gap-filling, signal-boosting, and benefit-expanding policies.

We can use Figure 3 to explain how each type of complementary policy can reduce GHG emissions cost-effectively:

Bar #1 (Gap-filler): Policy drives emissions reductions (equal to the width of the bar) from emissions sources that are *not covered* by the carbon price. It is *effective* because it drives additional mitigation: the carbon price would not have created incentives for this action, because it does not cover these emissions. The cost of this mitigation (equal to the height of the bar) is lower than the explicit carbon price; as a result, the policy is *cost-effective*.

Bar #2 (Signal-booster): The carbon price alone would not drive the emissions reductions from a given mitigation action (equal to the width of the bar), because its cost per tonne (height of the bar) is higher than the carbon price. However, the policy successfully addresses a market failure, and therefore lowers the cost of mitigation. As a result, its cost becomes low enough that the carbon price provides sufficient incentive to drive the action (i.e., its cost per tonne is less than *P**). The complementary policy is *effective*, because it "unlocks" additional emissions reductions. It is *cost-effective* if the benefit of addressing the market failure (i.e., additional emissions reductions) exceeds the cost of doing so (not pictured).

Bar #3 (Benefit-expander): Again, the carbon price alone would not drive the emissions reductions associated with a given

[11] A mitigation action's marginal abatement cost (MAC) measures the cost of reducing an additional tonne of GHG emissions under the action. MAC curves order mitigation actions by their MACs, from lowest to highest. MAC curves are used to provide an overview of the costs and emissions-reduction potential of various mitigation options.

mitigation action (equal to the width of the bar), because its cost per tonne (height of the bar) exceeds the carbon price. However, when the value of the *non-GHG co-benefits* is considered, its costs fall considerably. Therefore, once initiated, this seemingly costly action is both *effective* and *cost-effective*.

In sections 4 and 5, we explore how different types of complementarity can lead to different impacts on effectiveness and cost-effectiveness. In the remainder of this section, we discuss the two other key considerations for climate policies: *interactions* and *design*.

3.2 POLICY INTERACTIONS

Additional climate policies can interact with carbon pricing when they "overlap"—that is, when they apply to the same GHG emissions. This is especially relevant for signal-boosting and benefit-expanding policies; in contrast, gap-filling policies are usually intended to apply to different emissions from those covered by the carbon price. Importantly, additional policies interact quite differently with carbon taxes than they do with cap-and-trade systems. And they can also interact with other climate and non-climate policies. In some cases, overlapping policies may not lead to additional GHG mitigation.

With a carbon tax, complementary policies will drive further GHG reductions

Policies layered on top of a carbon tax generally do not interact with it in ways that undermine performance. These policies can improve effectiveness by creating additional incentives to reduce GHG emissions. If the incentives are greater or stronger than those created by the price of carbon, they will change behaviour above and beyond the carbon tax, and lead to additional reductions (Hood, 2013). These incremental emissions reductions also come at a cost—and the policy may or may not be cost-effective relative to alternatives. But these costs are not affected by policy interactions.

Consider the following example. British Columbia has implemented a low-carbon fuel standard (LCFS) for transportation fuels, in addition to its carbon tax.[12] The two policies overlap, in that they both apply to transportation emissions. Analysis from Wolinetz and Axsen (2014) suggests that the use of renewable fuels in B.C., as supported by the LCFS and renewable fuel mandate, reduced the province's annual GHG emissions by 0.9 Mt in 2012, *over and above* the effects of the carbon tax. These emissions reductions have come at a high cost—permit-trade data suggest that the costs of LCFS-driven emissions reductions are as much as $172 per tonne, well above the $30 per tonne imposed by the carbon tax (Government of British Columbia, 2016b).[13] Though these costs are very high, they are independent of the carbon tax.

With a cap-and-trade system, complementary policies do not necessarily drive further GHG reductions

The implications of policy interactions are different for cap-and-trade systems. Because the total number of emissions permits—and thus the allowable emissions—is fixed by the system's cap, complementary policies that overlap with a cap-and-trade system will not lead to *additional* GHG mitigation, thus undermining their effectiveness (Goulder & Stavins, 2010; Hood, 2013; Levinson, 2010).[14, 15] These policies may also interact with a cap-and-trade system to increase the overall costs of policy, thus undermining cost-effectiveness. These effects occur via the following mechanism:

1) The complementary policy changes the behaviour of emitters, leading them to adopt actions that reduce their own GHG emissions.
2) This mitigation leads to lower demand for emissions permits within the cap-and-trade system.[16]
3) The reduced demand for permits causes their market price to fall.
4) As a result of the price reduction, some mitigation actions now cost more than the carbon price, so this mitigation does not occur. In this way, the mitigation from the complementary policy displaces mitigation that would have otherwise occurred elsewhere within the cap-and-trade system.

[12] A low-carbon fuel standard (LCFS) is a regulation intended to reduce the carbon intensity of fuels. It stipulates the average carbon intensity of fuels that all fuel distributors must meet (e.g., B.C. and California require a 10% reduction in average carbon intensity across all fuel types by 2020). The LCFS is "flexible," in that it allows fuel manufacturers and distributors to meet the standard in whatever way is most economical for them. As such, it usually has provisions for compliance trading.

[13] To the extent that the policy successfully addresses market failures or has significant co-benefits, these direct abatement costs would overestimate the policy's overall costs.

[14] We assume here that jurisdictions do not decrease the number of available permits in a cap-and-trade system to reflect the GHG mitigation being driven by complementary policies. While this is certainly possible (and in fact desirable), there is no evidence that Western Climate Initiative members California, Ontario, and Quebec have any intention of adjusting their caps to reflect the effect of their complementary policies.

[15] One exception to this is when permits are auctioning at the system's floor price. This situation is discussed below.

[16] Signal-boosting policies that reduce the cost of mitigation actions that were already occurring under the cap-and-trade system are an exception to this. These policies do not change the demand for permits.

5) As a result, the overall impact on GHG emissions is nil. But because some of the mitigation actions have changed (and because they can be expected to have higher costs than what they displaced[17]) the overall cost of mitigation under the cap-and-trade system may rise.

The case of California's LCFS provides an example. It parallels the LCFS example from British Columbia discussed above, in that it also overlaps with the jurisdiction's carbon pricing policy, but is different because the carbon pricing policy is a cap-and-trade system. From 2011 to 2015, the LCFS reduced emissions by 9.2 Mt cumulatively (Yeh & Witcover, 2016). But unlike the case in B.C., this mitigation was *not additional*—it displaced mitigation that would have otherwise occurred within the cap-and-trade system. Yet the combination of policies likely has greater costs—and the same level of abatement—than the cap-and-trade system would have had operating on its own.[18] Indeed, the price of tradable compliance permits in the California LCFS, which approximates the per-tonne costs of emissions reductions, suggests that the emissions reductions were more expensive than those under the cap-and-trade system would have been. These LCFS permits traded at $62 per ton in 2015—more than four times the price of emissions permits under the state's cap-and-trade system at the time (CARB, 2016). If these higher costs are not justified by offsetting benefits, or by overcoming specific market failures, then the policy left the total quantity of mitigation unchanged while raising overall costs.

If a cap-and-trade system's cap is not binding, complementary policies may drive further GHG mitigation

Cap-and-trade systems in Ontario, Quebec, and California all have a price floor (i.e., a minimum selling price for auctioned permits) that rises 5% annually (in real, inflation-adjusted terms). When permits are selling above the price floor, the system's cap is binding; complementary policies that overlap with the cap-and-trade system will therefore displace mitigation that would have occurred elsewhere.

However, if permits are only selling at the price floor, it suggests an over-allocation in the permit market and a cap that is *not* binding.[19] In this situation, the system effectively behaves like a carbon tax. GHG mitigation from a complementary policy is therefore additional to GHG mitigation from the cap-and-trade system.[20]

To return to our example of LCFS policy in California, because permits in California's cap-and-trade system sold above the system's price floor between 2011 and 2015, the reduction of 9.2 Mt attributable to the LCFS during this period was not additional. However, since early 2016, permit prices have not risen above the price floor. If this remains the case for the rest of the permits' compliance period (which ends December 31, 2017), then any mitigation attributable to the LCFS during this time *will* be additional.

There is an important caveat here. Under a cap-and-trade system, either the cap is binding and complementary policies do *not* lead to additional mitigation or there is slack in the permit market and complementary policies *do* lead to additional mitigation. In the first case, the purchase of a permit does not correspond to a mitigation action being taken; but in the latter, it does. Therefore, under a cap-and-trade system, additional mitigation can come from complementary policies (when permits are at the floor price) or from buying permits (when prices are above the floor), but never from both at the same time.

Interactions affect linked cap-and-trade systems in a slightly different way

The interactions discussed above can be even more complex when the cap-and-trade system is *externally linked* (i.e., when permits can be traded between jurisdictions). Quebec's cap-and-trade system, for example, is linked to California's, and Ontario plans to join the common system in 2018. In linked systems, overlapping policies can interact with cap-and-trade to affect the cost-effectiveness of mitigation, but also the permit flows that occur between jurisdictions. The mechanism works as follows:

1) The cap determines total emissions for the system. If permits are auctioning above the price floor, complementary policies affecting covered emissions do not lead to further emissions reductions.
2) In the jurisdiction where it is implemented, the complementary policy triggers emissions reductions that reduce the demand for permits. If the jurisdiction is a net importer of permits, this reduced demand will cause it to *import fewer* permits. If the jurisdiction is a net exporter of permits, reduced demand will

[17] The key exception to this is when new policies are genuine complements; that is, they provide offsetting benefits by addressing market failures within the cap-and-trade system's coverage, or by delivering co-benefits. In these cases, the policies can *improve* the cost-effectiveness of the mitigation that occurs under the cap-and-trade system. We explore this possibility in our case studies in Section 5.

[18] Notably, California designed the policies not in sequence but as a package. In other words, policymakers may have *accounted* for the policy interaction by implementing a more aggressive cap on emissions than they would have in the absence of the LCFS.

[19] This over-allocation could be driven by a number of factors, including the cap was set too loosely, mitigation is exceeding expectations, or complementary policies are driving a significant amount of mitigation.

[20] An exception is when excess permits are banked for future compliance under the cap; while the cap might not be binding in a given year, it could still bind over a longer period of time.

cause it to *export more* permits. These changes in net permit flows imply corresponding changes in net financial flows. For a net permit importer, financial transfers to the exporting jurisdiction fall; for a net exporter, financial transfers received from the importing jurisdiction rise.
3) In either case, total GHG mitigation in the overall system remains unchanged, but the *distribution* of emissions is affected: more emissions reductions occur in the jurisdiction that implemented the policy, and fewer in the jurisdiction with which it trades.
4) Because the complementary policy causes the mitigation actions occurring under the cap to change (and because they have a different cost profile than what they displaced), the overall cost of mitigation under the cap-and-trade system is likely to rise. [21]

Consider, for example, the case of a new (proposed) flexible fuel mandate (similar to British Columbia's and California's LCFS policies) in Ontario (Government of Ontario, 2016). The fuel mandate will apply to emissions covered under the cap-and-trade system. Under the linked cap-and-trade systems, Ontario is expected to be a net importer of permits from California (Sawyer et al., 2016). The expected impact of the new fuel mandate is thus more emissions reductions *within Ontario*, fewer in California, but the same quantity of emissions in the system overall (assuming the system's total cap binds). The economic implications of this are higher overall costs of abatement for the system and higher costs of compliance for Ontario (i.e., unless there are co-benefits or benefits from boosting the carbon pricing signal to justify the policy) but smaller financial flows from Ontario to California.

While the shifting of GHG mitigation between jurisdictions through complementary policy serves no global environmental function, it may still have other advantages. Favouring higher-cost, local mitigation over lower-cost mitigation from a linked jurisdiction raises overall mitigation costs. However, if a complementary policy addresses market failures or offers co-benefits in the implementing jurisdiction, these higher mitigation costs might be justified. For example, public investment in R&D might raise costs in the short term but lower costs in the longer term by yielding innovations that lower the cost of mitigation.

Non-pricing climate policies can interact with one another in case-specific ways

In addition to potential interactions with carbon pricing, climate policies can also interact with one another, and also with non-climate policies. These interactions can have implications for the policies' effectiveness and cost-effectiveness, and—especially in the case of non-climate policies—can cause other impacts as well.

Interactions between policies can play out in multiple ways. In general, interaction issues are most significant in the case of regulatory policies that define allowable quantities of GHG emissions or levels of emissions performance. We consider two examples below to explore potential nuances.

To return to our LCFS example, British Columbia has an LCFS and a renewable fuel mandate, both of which interact with the province's carbon tax and with each other. Both policies create compliance obligations for fuel distributors, so the GHG mitigation that the policies drive can overlap (i.e., the mitigation driven by the LCFS and the renewable fuel mandate may, at least in part, be one and the same). Because of this overlap, the *incremental* effectiveness of the LCFS policy may be limited by the fact that the province already had a renewable fuel mandate in place when the policy was introduced.[22] A well-designed LCFS policy would consider the implications of these types of interactions in its design and evaluation (and in that of the renewable fuel mandate as well).

Interactions can also occur between policies implemented by different levels of government. For example, if the federal government were to implement a policy mandating that a certain percentage of national vehicle sales be Zero Emission Vehicles (ZEVs), as some have suggested (Axsen, 2017; Jaccard, 2016), this could interact with Quebec's similar policy regulating the sale of ZEVs (Hall, 2016).[23] While the federal policy could allow for flexible compliance across provinces, the Quebec policy might require a disproportionate share of the compliance to occur in Quebec. This shift would affect the distribution of emissions reductions across provinces and potentially undermine the cost-effectiveness of the federal policy. Therefore, any federal policy on ZEVs should account for the potential effects of interactions with Quebec's ZEV policy in its design, as well as interactions with other relevant policies (e.g., federal Corporate Average Fuel Economy regulations). We return to complications arising from the interaction of federal and provincial policies in Section 6.

[21] Complementary policies that address market problems or have offsetting benefits are again an exception to this.
[22] In addition, the renewable fuel mandate constrains the way in which the LCFS's performance benchmark is achieved, so its presence may reduce the cost-effectiveness of the LCFS.
[23] We revisit Quebec's ZEV mandate in Section 5.2, where we explore Quebec's electric vehicle subsidies as a case study.

3.3 DESIGN FEATURES

A policy's design can have important implications for its effectiveness and cost-effectiveness. Indeed, the design of a given policy instrument can be as or more important than what type of instrument is used (Goulder, 2013). Well-designed policies will generally drive more emissions reductions and have lower costs. When it comes to policy performance, five design features are particularly significant: stringency, coverage, flexibility, predictability, and governance.

Stringency increases policy effectiveness

A policy's *stringency* drives both its effectiveness, in terms of reducing GHG emissions, and the degree of difficulty that governments, businesses, or households will likely face in complying with it. Both current levels of policy stringency and how that stringency changes over time have implications for emissions reductions.

The implications of stringency for the overall effectiveness of a particular policy are clear: a more stringent policy results in more emissions reductions. The implications for cost-effectiveness, however, are less clear. Additional emissions reductions may or may not be cost-effective, depending on the details of the policy.

For carbon pricing, the level of stringency is explicit: Under a carbon tax, stringency is reflected by the rate of the carbon tax; in a cap-and-trade system, it is the quantity of emissions allowed under the cap (which then determines the price of permits). In both cases, the level of stringency can increase over time, via an increasing carbon tax or a declining emissions cap.

For non-pricing policies, however, the degree of stringency may be less obvious. It could be the level of a performance standard, the intensity of an inspection and reporting regime, the degree to which a production subsidy is provided, or some other factor. For example, in Ontario's phase-out of coal-fired electricity, the stringency of the policy was defined by the timeline for phase-out—the more aggressive the timeline, the more stringent the policy. Canada's 2012 federal regulation of coal-fired electricity (Environment Canada, 2012) had relatively weak stringency—it called for coal plants to close (or be retrofitted with carbon capture and storage) only at their "end of useful life" (usually 50 years, with milestones in 2019 and 2029). However, in November 2016, the federal government announced a policy with far greater stringency—the phase-out of *all* coal-fired electricity by 2030 (Government of Canada, 2016b). This roughly mirrors the timeline that Alberta is planning for its own phase-out of coal, a policy examined as a detailed case study in Section 5.3.

Broader coverage improves effectiveness

A policy's *coverage* defines the share of GHG emissions to which it applies. A policy with narrow coverage will focus on a specific subset of technologies or activities (e.g., a regulation focused only on fuel-oil furnaces), while a policy with broader coverage will focus on the larger set of technologies or activities (e.g., a regulation focused on all types of home-heating technologies).

Like stringency, coverage has clear implications for policy effectiveness, but unclear implications for cost-effectiveness. All else being equal, broader coverage means greater emissions reductions. But whether or not these additional GHG reductions are cost-effective will depend on the policy's specific design and characteristics.

With carbon pricing, broader coverage leads to more cost-effective mitigation. But for non-pricing complementary policies, there may be good reasons to keep coverage narrow in certain cases. If there is a specific market failure to be overcome with signal-boosting policy or a specific co-benefit to be realized, these outcomes might be more cost-effectively realized with a tightly focused policy. Further, policies with broad coverage are more likely to overlap and interact with carbon pricing. These interactions can complicate policy design and potentially reduce policy performance.

Flexibility reduces the costs of policy

Flexibility generally refers to the extent to which emitters have choices regarding how they comply with a policy. Policies that emphasize flexibility typically focus on outcomes (i.e., performance standards) rather than means (i.e., specific technologies or activities) (Gunningham & Holley, 2016; Ribeiro & Kruglianskas, 2015). Flexibility can be introduced through market-based mechanisms such as credit trading, banking, and borrowing (Newell, 2015). Policies can be flexible across agents, technologies, and time. We discuss each dimension in turn.

First, policy can be flexible across *agents*—typically household or businesses. A policy that is flexible across agents does not specify which emitters reduce which emissions under a regulation, or narrowly specify eligibility for subsidies (Ribeiro & Kruglianskas, 2015). Instead, a flexible policy allows agents themselves to choose who takes an action, generally leading to those with lower costs taking more actions. One flexible approach is regulations with tradable permits or obligations (Jaccard et al., 2016). For instance, ZEV standards mandate that manufacturers produce and sell a certain number of zero-emission vehicles. Flexibility—through trading permits—allows firms with low costs to produce and sell the ZEVs, and to sell excess permits to firms with higher compliance costs. This flexibility ensures that the outcome (i.e., more zero-emission vehicles) is achieved at the lowest economic cost (Gomez-Baggethun & Muradian, 2015).[24]

Second, flexible policy is not prescriptive with respect to *technologies*. When a regulation or subsidy focuses on a specific type of technology, it limits the incentive for firms to innovate and develop new technologies that can achieve objectives at lower cost (Ribeiro & Kruglianskas, 2015). In addition, government does not generally have access to the required information to decide whether one technology has lower costs relative to another (e.g., renewable electricity from wind versus solar). Flexible policies focus on the intended objectives, not which technologies must be used to achieve those objectives.[25] For example, when procuring electricity, instead of focusing on specific modes of generation (e.g., solar, wind), governments and utilities can solicit bids for renewable or zero-emissions electricity in general. This technology-neutral approach allows the market to determine what the most cost-effective option is.

Third, policy can be flexible across *time* by allowing agents some leeway in determining when they will reduce their emissions. Creating regulations with rigid timelines for adherence can lead to higher costs. In some cases, it may be possible to achieve the same policy outcome, but under certain conditions allow firms to delay their compliance obligations (perhaps paying a penalty) or to advance them (perhaps in exchange for an offsetting benefit). The LCFS in California, for example, allows obligated parties to bank extra compliance credits (which never expire) in years when blending low-carbon fuels is more feasible (International Emissions Trading Association, 2015). This reduces the compliance costs in years where low-carbon fuels are less available or costlier to acquire (Lade & Lawell, 2015).

Predictable policy leads to more emissions reductions and lower costs

Predictability is the extent to which a policy establishes clear incentives over the longer term. It has three main dimensions: transparency, credibility, and simplicity (Ribeiro & Kruglianskas, 2015).

Transparent policies clearly lay out how the policy will work and the criteria under which changes to it might occur (OECD & World Bank, 2015). If the program is tied to revenues from carbon pricing schemes, the implications of potential revenue shortfalls should be made clear. *Credible* policies, on the other hand, exist when firms and households are confident governments will consistently implement, enforce, and maintain the policy over time. If emitters instead believe that decisions to increase or decrease the stringency of the policy (or even to terminate it) could become politicized, incentives from the policy become uncertain over time, diluting its impact. This risk can be limited through legislation or the use of arm's-length bodies for policy oversight. Finally, *simple* policies are easy to understand, both now and in the future. Simplicity makes it easier for emitters to predict how they will be impacted by a policy, and how they should respond.

Firms' and households' expectations about future policy will affect their investment choices and their incentives to innovate. As a result, predictability has implications for both policy effectiveness and cost-effectiveness. For example, if oil and gas producers expect that their fugitive methane emissions will be subject to more-stringent regulation in the future, they may choose a higher standard of leak-detection technology for projects they are currently planning. The policy's predictability makes it more cost-effective: the firm does not need to install one type of technology now and another when the regulation is announced in the future. Predictability in this example also increases effectiveness: firms reduce fugitive emissions earlier (possibly even in advance of the regulation taking effect) by adopting the superior technology in the first place.

[24] While a ZEV mandate's flexibility across technologies can lead to more cost-effective uptake and development of zero-emission vehicles, it does little to address the behaviour of car owners. For example, while driving less might also lead to cost-effective mitigation, the regulation doesn't promote this (i.e., it is inflexible across *behaviours*). To address this shortcoming, a policy *package* may be needed: with policies that decrease the emissions intensity of the vehicle fleet (e.g., ZEV mandates and Corporate Average Fuel Economy standards), policies to encourage car owners to drive less (e.g., carbon pricing, and perhaps congestion pricing), and policies to help decrease individuals' reliance on their personal vehicles (e.g., increasing the availability of transit, walking and cycling alternatives). However, in the same way that the cost-effectiveness of individual policies matters, the cost-effectiveness of an overall policy package is also important. The design of a coherent climate policy package is discussed in Section 6.

[25] Some technologies may face specific market failures that others do not. In these cases, Fischer et al. (2013) suggest that a balance must be struck between providing broad support to a suite of emerging technologies and helping specific technologies overcome key market failures.

Good governance mechanisms improve policy performance

A variety of governance features can affect a policy's overall effectiveness and cost-effectiveness. Here we focus on three specific elements: periodic review, improvement, and scope for termination. Notably, each of these principles is embedded in the Australian government's strategy for reviewing and assessing policies intended to complement carbon pricing (Wilkins, 2008).

Principles of good regulatory governance suggest that existing laws and regulations should undergo *periodic review*, to allow policymakers to determine how well they are performing (OECD, 2012). This type of ex-post analysis assesses how well policies have met their objectives, and at what cost. Review and evaluation is a central part of policymaking in Canada and is codified in the *Standard on Evaluation for the Government of Canada* (Treasury Board of Canada Secretariat, 2009). This document outlines the specific process, methods, and objectives of an evaluation, along with the expectations for consultation and feedback. The Federal Renewable Fuel Standard, for example, was evaluated using this standard (ECCC, 2016).

Once a policy or program has been reviewed and evaluated, a critical next step is to apply the findings in a way that improves policy performance over time. Again, this step is formalized in the federal regulatory process, whereby evaluations are expected to "support policy and program improvement, expenditure management, Cabinet decision-making, and public reporting" (Treasury Board of Canada Secretariat, 2012). In the case of climate policies, evidence from periodic review may suggest that policies can be calibrated to drive more emissions reductions at lower cost. For example, Ontario's Feed-in Tariff (FiT) program initially experienced an unexpectedly large uptake. Recognizing that the FiT rate was likely higher than necessary, policymakers reduced it (Government of Ontario, 2012), thereby improving the policy's cost-effectiveness.[26]

Policy stringency may also need to be periodically recalibrated over time to remain in line with increases in the explicit carbon price. Aligning a policy's stringency with the carbon price can help to keep overall GHG mitigation cost-effective (we discuss the cost-effectiveness of the overall policy package in Section 6).

Lastly, provisions to *terminate* specific policies can help to ensure overall effectiveness and cost-effectiveness (OECD, 2012). Over time, the performance of a policy is likely to change as circumstances evolve. If the policy is no longer effective, or if other instruments can better meet the policy objectives, having a mechanism in place to terminate a policy is critical. While it is not uncommon for regulations, and particularly subsidies, to come with a fixed end date, built-in provisions for early termination of an underperforming policy are far less common. The conditions under which a policy would be terminated should be clearly stated. Policy termination decisions should be made under a transparent review process that includes stakeholder consultation.

Biofuel policies in Canada illustrate the importance of having built-in mechanisms for review or termination. In the mid-2000s, the federal government and five provincial governments initiated subsidy programs to encourage the production of ethanol and biodiesel. These provincial and federal production subsidies were introduced with fixed end dates, all of which have already ended or will end soon. Provincial and federal governments also enacted renewable fuel mandates during the past decade to coincide with the supply-side production subsidies. Recent analysis by Canada's Ecofiscal Commission (2016b) finds that these climate policies (in addition to production subsidies) have been costly ($180 to $185 per tonne of CO_2e for ethanol, and $128 to $165 per tonne for biodiesel). Yet despite these high costs—and with unclear co-benefits to justify them—renewable fuel mandates have been enacted indefinitely with no specified mechanisms for formal review.

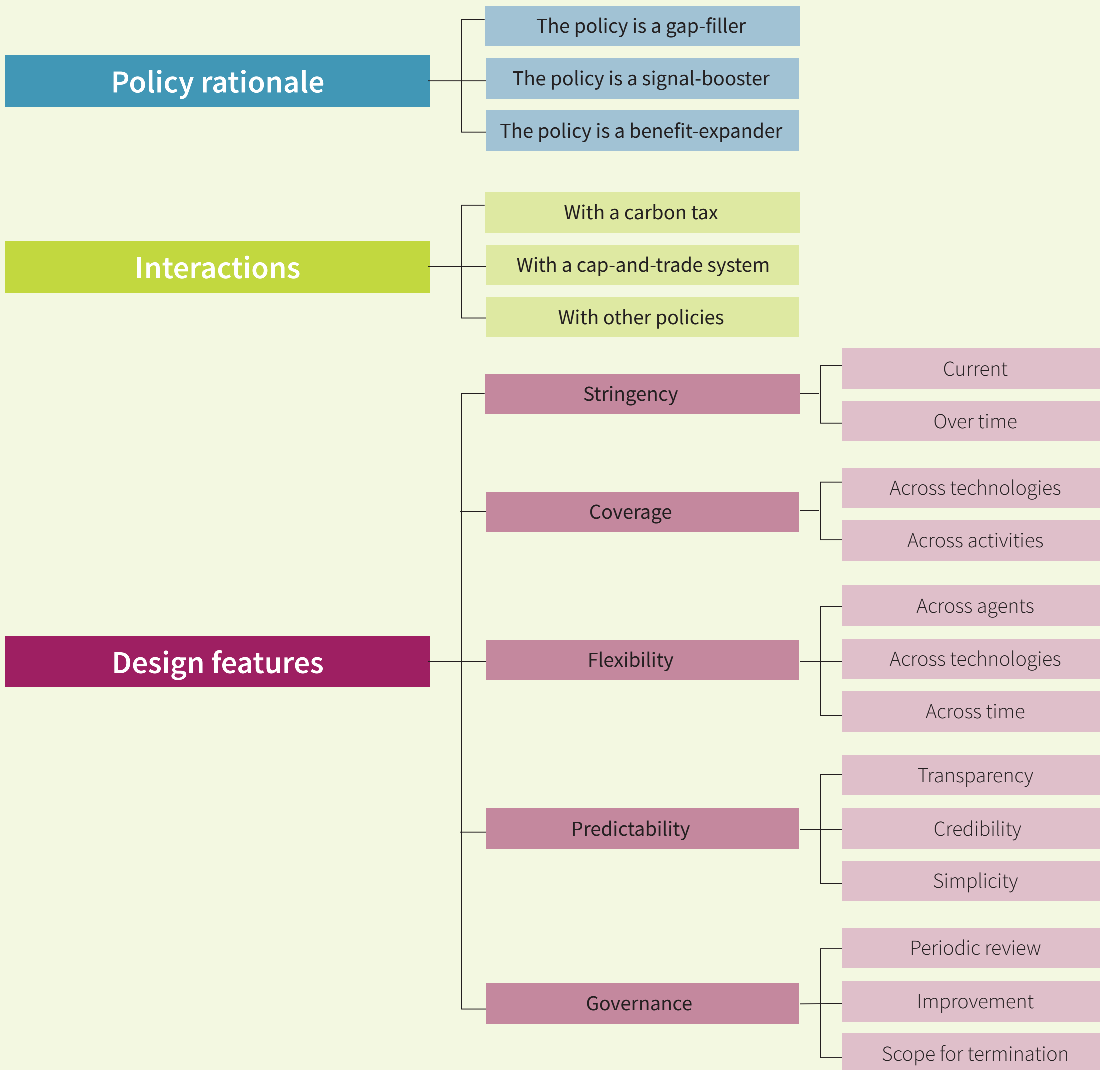
The three governance principles of regular review, improvement, and scope for termination are especially important for climate policy. How low-carbon technologies evolve over time will determine the costs of mitigation. But because technological change is usually uneven and unpredictable, and proceeds at different rates in different parts of the economy, policies must be regularly revisited and recalibrated to ensure they are working effectively and cost-effectively. Mechanisms for regular review, improvement, and, if called for, termination can help ensure that policies are optimally responding to technological change; these mechanisms can be particularly important in cases where policies create vested interests.

3.4 SUMMARY OF CONSIDERATIONS

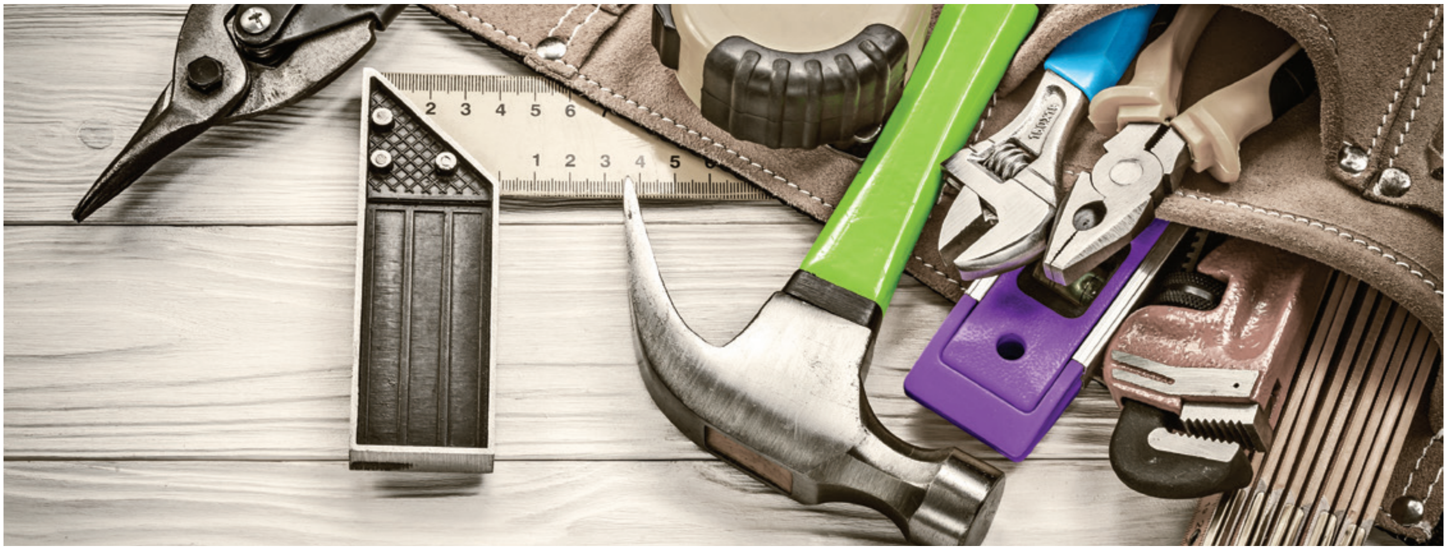
There is clearly much to consider when assessing the complementarity of additional, non-pricing climate policies. Not all such policies will make the grade in terms of effectiveness and cost-effectiveness. Figure 4 provides an overview of the three main considerations and their sub-elements. In the following section, we present a tool for applying these considerations to the evaluation of policies.

[26] At the same time, while this was a valuable governance action to improve policy cost-effectiveness, Ontario's Auditor General noted that early warnings about the tariff rate were ignored (Office of the Auditor General of Ontario, 2015), which suggests there were shortcomings in the policy's larger governance procedures.

Figure 4: Considerations for assessing the complementarity of climate policies



The figure summarizes the elements of our framework for assessing the complementarity of any additional, non-pricing GHG policy. The three broad categories are the policy's rationale, how the non-pricing policy interacts with other policies (including the carbon price), and the various design features of the policy.



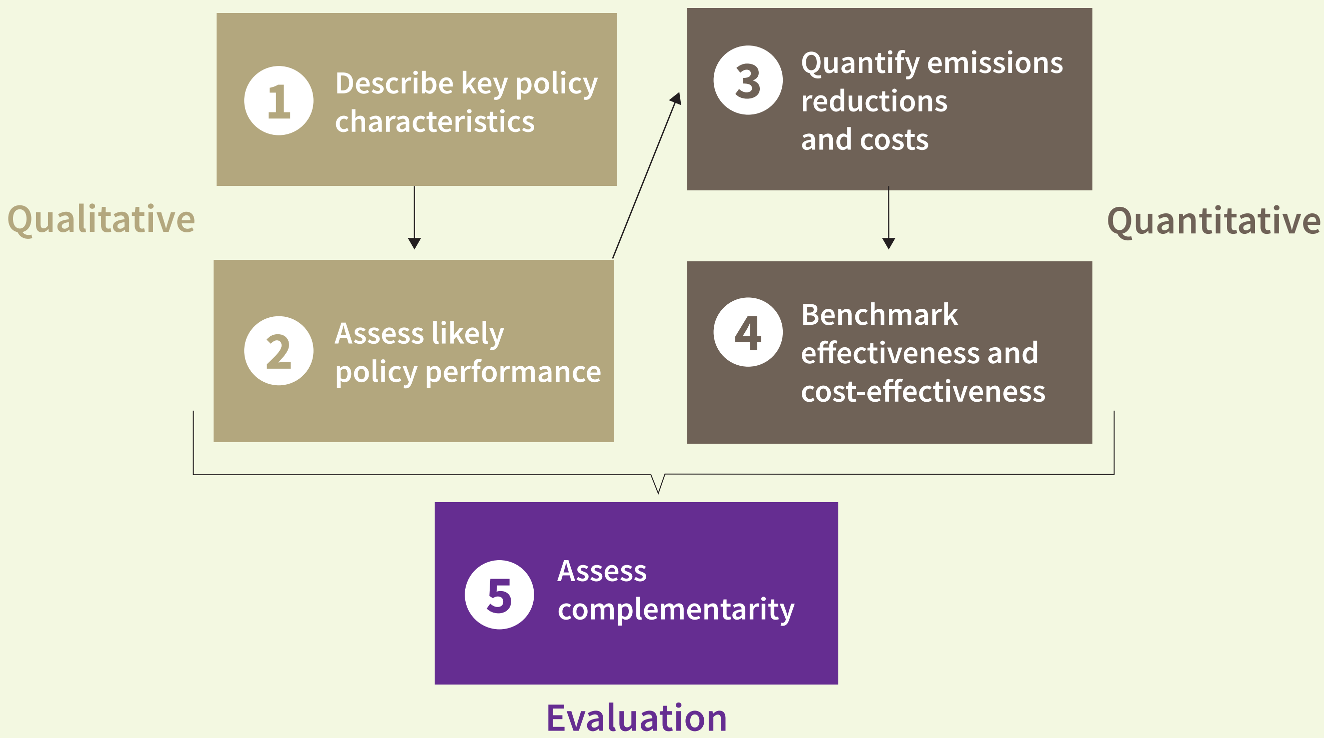
4 A PRACTICAL GUIDE TO POLICY EVALUATION

This section integrates the three key considerations outlined in Section 3—policy rationale, interactions, and design—into a practical framework for the evaluation of policies implemented in addition to carbon pricing. It applies both qualitative and quantitative approaches to help provide a clear picture of a policy's performance.

The framework offers a practical tool for understanding and contextualizing different climate policies, for assessing their performance in terms of effectiveness and cost-effectiveness, and ultimately for identifying which policies are genuine complements to carbon pricing.

Figure 5 summarizes the five main components of the framework (which also map to the parts of this section). Each represents a step in analyzing and evaluating a given policy. The qualitative phase informs the quantitative, helping to shape the analysis and interpret its results, while both contribute to overall policy evaluation.

Figure 5: Framework for policy evaluation



The figure summarizes the five key steps in our process for evaluating potentially complementary GHG policies. The case studies in Section 5 follow this framework.

STEP 1

1 Describe key policy characteristics

As outlined in Section 3, three main considerations affect a policy's performance: the rationale for its complementarity, its interactions with other policies, and its design features. Table 5 provides a set of guiding questions designed to help identify a policy's key characteristics. The intention here is not to definitively assess the policy's outcomes, but rather to identify the key factors that will inform subsequent steps of the evaluation process.

<table>
<tr><th colspan="4">Table 5: Guiding questions for describing key policy characteristics</th></tr>
<tr><th>Considerations</th><th colspan="3">Guiding questions</th></tr>
<tr><td>What is the rationale for the policy?</td><td colspan="3">Gap-filling policies
• Does the policy apply to emissions not already covered by a carbon pricing policy?
• Could the coverage of carbon pricing be extended to cover these emissions?
Signal-boosting policies
• What problem is the policy seeking to address? Why is carbon pricing unable to solve it?
• Is the problem a genuine market failure?
• Are other policy solutions available to address the problem?
Benefit-expanding policies
• What non-GHG benefits can the policy deliver?
• Are these objectives better achieved through separate, non-GHG policies?</td></tr>
<tr><td>How does the policy interact with other policies?</td><td colspan="3">Interactions with carbon taxes
• Does the policy apply to the same emissions covered by the carbon tax?
• Will the resulting emissions reductions occur under the carbon tax anyway?
• Would they occur if the carbon tax were higher?
Interactions with cap-and-trade systems
• Does the policy apply to the same emissions covered by the cap-and-trade system?
• Will the resulting emissions reductions occur under carbon pricing anyway? Would they occur if the carbon price under the system were higher (i.e., via a tighter emissions cap)?
• Will emissions reductions be displaced under the cap (i.e., is the system's cap binding)?
• Is the cap-and-trade system linked—through cross-border permit trade—with other carbon pricing systems? If so, is the implementing jurisdiction a net importer or net exporter of permits?
Interactions with other policies
• Does the policy apply to the same emissions covered by another climate policy?
• Are there emissions reductions that might be displaced as a result of this overlapping coverage?
• Does the policy interact with non-climate policies? What are the implications of this interaction?</td></tr>
<tr><td rowspan="6">What are the key design features of the policy?</td><td>Design features</td><td>For regulatory instruments</td><td>For subsidy instruments</td></tr>
<tr><td>Stringency</td><td>• What are the requirements for emissions or performance or technologies?
• How do these requirements change over time?</td><td>• How large an incentive does the subsidy provide?
• How does the incentive change over time?</td></tr>
<tr><td>Coverage</td><td colspan="2">• Is the policy focused on a specific set of activities or is it more general?
• What sector(s) does it cover, and what portion of this sector's emissions?
• Will this coverage change over time?</td></tr>
<tr><td>Flexibility</td><td>• How technology-specific is the policy?
• Can emitters trade compliance obligations?
• Is there flexibility across time?</td><td>• Does the policy focus on specific technologies or actions?
• To what extent are certain actors given preferential access?</td></tr>
<tr><td>Predictability</td><td colspan="2">• Are the policy's future characteristics accurately predictable for emitters?
• Have conditions under which the policy could change been made transparent?
• To what extent is the long-term existence of the policy seen as credible?</td></tr>
<tr><td>Governance</td><td colspan="2">• Does the policy have scheduled periodic reviews, including ex-post performance assessment?
• Does the policy have mechanisms for improvement over time?
• Does the policy have clear mechanisms for termination?</td></tr>
</table>

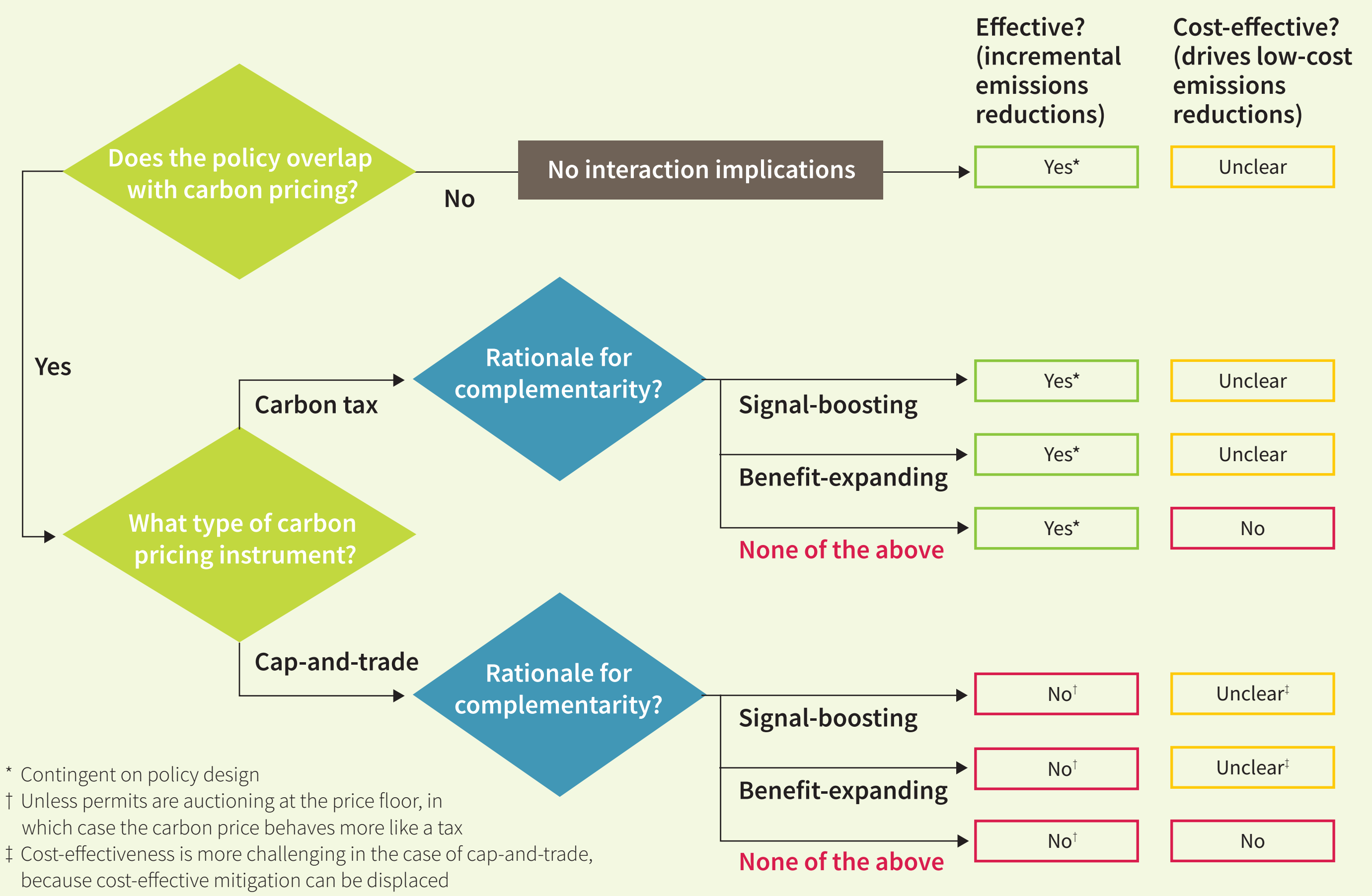
STEP 2

2 Assess likely policy performance

As we noted in Section 3, the key characteristics of a climate policy—its rationale, interactions, and design—are directly related to its performance. Yet these three factors interact with one another in potentially complex ways. None of the factors on its own serves to identify whether a policy will be a genuine complement to carbon pricing. Only by combining all three can a more relevant picture emerge. (And as we will see in the case studies in Section 5, a *full* picture requires integrating qualitative and quantitative analyses.)

First, consider the implications of both a policy's **rationale** and the nature of its **interaction** with a carbon pricing policy. Figure 6 maps out potential implications. If a non-pricing policy expands the coverage of climate policy, addresses market failures, or delivers co-benefits, then it *may* be cost-effective. Policies that meet *none* of these criteria, however, are *not* cost-effective; the same emissions reductions could instead be achieved at lower cost through carbon pricing. As Figure 6 illustrates, meeting one of these three criteria for policy rationale is a *necessary* but not *sufficient* condition for cost-effectiveness. Effectiveness, on the other hand, is more straightforward: whether or not a policy leads to *additional* reductions will depend on whether it interacts with carbon pricing and, if it does, what *type* of carbon pricing instrument it interacts with.

Figure 6: Implications of a policy's rationale and interactions with carbon pricing policies

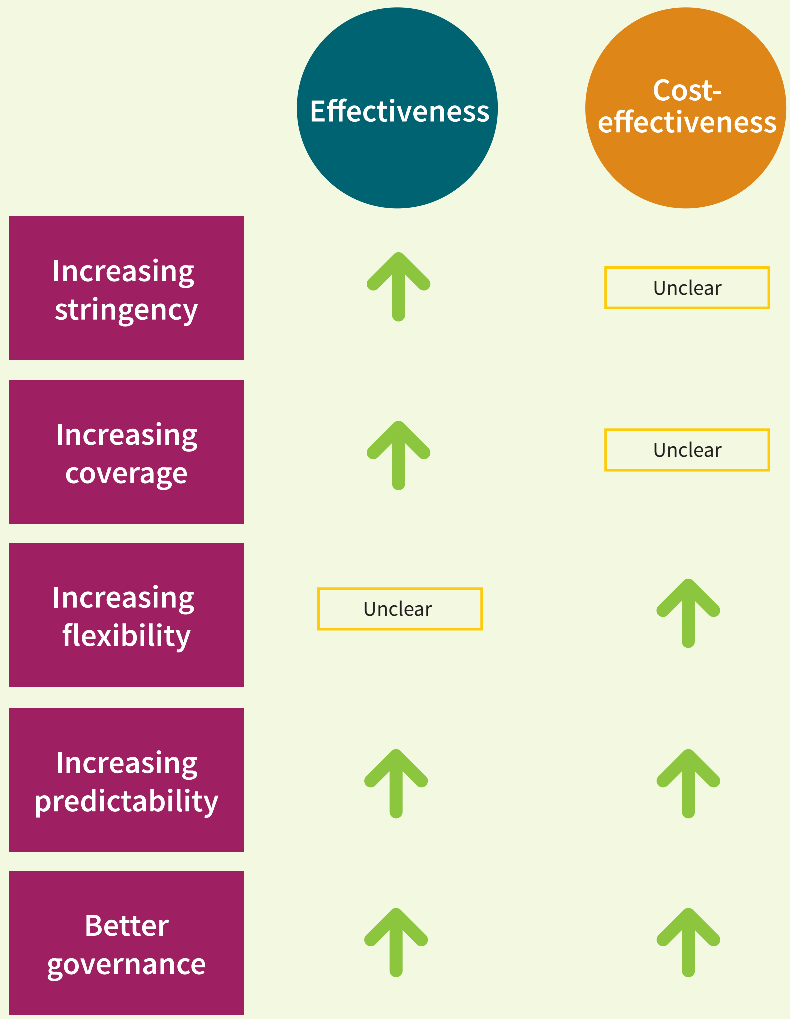


* Contingent on policy design
† Unless permits are auctioning at the price floor, in which case the carbon price behaves more like a tax
‡ Cost-effectiveness is more challenging in the case of cap-and-trade, because cost-effective mitigation can be displaced

The figure illustrates the economic and environmental implications of policies given their rationale and the type of carbon pricing instrument with which they interact. Gap-filling policies (and some benefit-expanding policies) do not interact with carbon pricing. Signal-boosting and benefit-expanding policies will typically not drive additional emissions reductions in combination with a cap-and-trade system, though they may reduce overall costs.

As illustrated in Figure 7, the ultimate effectiveness of a policy depends on its **design**. Even policies with a clear rationale for complementarity that interact coherently with a carbon price are unlikely to perform well—either in reducing GHG emissions or in minimizing costs—if they are poorly designed. Figure 7 summarizes how the policy's design features (as identified in Step 1) can be expected to affect policy performance.

Figure 7: Implications of policy design for effectiveness and cost-effectiveness



The figure illustrates economic and environmental implications of key design features.

Complementary policies would ideally satisfy all five design criteria. However, for most complementary policies, there will usually be trade-offs between design features. For example, designing clear mechanisms for adjustment over time might also make a policy less predictable. And increasing the flexibility of a policy may compromise its stringency (Burtraw et al., 2016). Or, if making a policy more flexible also makes it more complex, it may reduce its predictability.

Working a policy through figures 6 and 7 provides insight into how it can be expected to perform. When paired with the quantitative analysis in steps 3 and 4, this qualitative assessment facilitates an informed, integrated, and holistic assessment of policy complementarity.

STEP 3

3 Quantify emissions reductions and costs

The third step of the framework is to quantify the expected impacts of policies both in terms of emissions reductions and their associated costs. Our intent here is not to describe modelling methodologies in detail, but to consider more general principles for the quantitative policy analysis. For more details on specific approaches to quantifying emissions reductions and costs, see the case studies in Section 5.

Effectiveness is measured in tonnes of GHG emissions reduced. Emissions reductions are the difference between two cases: 1) emissions levels under the policy (i.e., the *policy* case); and 2) emissions levels in the absence of the policy (i.e., the *counterfactual*). Developing these alternate scenarios invariably requires assumptions and modelling, and therefore it can be difficult to quantify emissions reductions with precision. We explore some of these approaches in Section 5, where we evaluate three case studies.

An extra caveat is required here. We are interested in cases where additional, non-pricing climate policies are layered on top of a carbon pricing policy. The relevant emissions reductions are those resulting from the *incremental* policy, not the *total package* of policies. In other words, both the *counterfactual* and *policy* cases include the carbon price policy. Any difference in emissions between the two is attributable to the additional policy.

To assess whether a policy reduces emissions **cost-effectively**, we must first quantify its costs. A convenient metric here is the policy's *implicit price of carbon*. The implicit price of carbon is the net cost of the policy divided by the emissions reduced, measured in dollars per tonne of GHGs avoided (OECD 2013a; Vivid Economics, 2010). A policy's implicit carbon price can be compared to the explicit carbon prices under a carbon tax or cap-and-trade system (Parry & Small, 2015; Wilkins, 2008). Benchmarking a policy's costs in this way allows us to comment on its cost-effectiveness.

We compute the implicit carbon price as the net social cost of policy averaged over the policy's attributable GHG mitigation. Note that net social costs are the direct costs of the policy less whatever non-GHG benefits might exist. The implicit carbon price is therefore:

Implicit carbon price = (Costs of policy – Non-GHG benefits of policy) / (Emissions reduced)

We might consider several kinds of economic costs in the numerator. Households and businesses face costs in complying with a regulatory policy. Governments face fiscal costs in funding subsidies but also administrative costs in terms of the costs of running and operating the policy.[27] From a broader economic perspective, policies also have efficiency costs, because governments often raise the funds needed for subsidies by using "distortionary" taxes that impose a cost on the economy. At the same time, however, the policy may have offsetting non-GHG benefits, such as reduced health-care costs or greater economic development. A policy's non-GHG benefits should be subtracted from its direct costs to provide a full picture of its total net cost to society.[28]

27 When considering the economic cost of subsidies, it is important to avoid double counting. For example, the Alberta government is planning to offer rebates toward the purchase of efficiency lighting, insulation, and appliances (Government of Alberta, 2017). In this case, it is consumers who pay the cost of the product. The subsidy itself is a *transfer* from taxpayers to these consumers, and is not an overall economic cost. There may, however, be an economic cost associated with the form of the taxes used to raise the revenues used to fund the subsidies.

28 In our estimation of implicit carbon prices, we calculate a policy's average, rather than marginal, abatement cost. In principle, the marginal cost matters most in terms of assessing cost-effectiveness. In practice, however, average costs are a more pragmatic metric for policy analysis. For the emissions reductions resulting from each policy, there is a wide range in costs across individual businesses, households, and emissions reductions, and it can be unclear what level of resolution is most appropriate to consider the distribution of costs. As a result, marginal costs are challenging to estimate in practice. We therefore focus on average costs when estimating a policy's implicit carbon prices.

STEP 4

4 Benchmark policy performance

How can policymakers interpret the emissions reductions and costs calculated above? Effectiveness is relatively straightforward. Each tonne of GHG emissions reduced contributes toward efforts to avoid the costs of climate change, so the more GHGs reduced, the more effective the policy. Assessing cost-effectiveness, however, is more complicated.

In Step 3, we explored how costs of emissions reductions could be calculated by estimating the policy's implicit carbon price. But with what should this implicit carbon price be compared? Three different benchmarks are relevant, each with different implications. Figure 8 summarizes their implications for assessing the cost-effectiveness of a complementary policy.

1. The current carbon price. The first benchmark for assessing the cost-effectiveness of a policy is the level of the carbon price that it is intended to complement (whether the rate of a carbon tax or the price of permits in a cap-and-trade system). A complementary policy with an implicit carbon price that *exceeds* the current explicit price on carbon is delivering mitigation at higher costs than mitigation delivered by the carbon price.

In British Columbia, the explicit price of carbon is $30 per tonne. In Alberta, it is $20 and will be $30 by 2018. In Ontario and Quebec, the carbon price is around $18.50 per tonne, though rising gradually over time. And in response to the recent federal announcement, carbon prices in those provinces with a carbon tax will rise to $50 per tonne by 2022.

2. The social cost of carbon. The cost to society of an extra tonne of GHG emissions—the social cost of carbon (SCC)—is a second useful benchmark. The SCC can also be seen as the benefit to society of *avoiding* one tonne of GHG emissions. If a policy's implicit carbon price exceeds the SCC, then the social costs of the policy would exceed the social benefits and, according to this benchmark, would be too expensive.

Despite the complexity of measuring the SCC (and the inevitable imprecision of estimates), it is a widely accepted measure and used in the social cost–benefit analysis of climate policies.[29] Environment and Climate Change Canada (ECCC) uses an estimate of the SCC in all of its Regulatory Impact Analysis Statements dealing with GHG emissions. ECCC develops its own estimates of the SCC in collaboration with other official bodies, including the U.S. Environmental Protection Agency.

ECCC (2016) estimates a central value of the SCC in 2016 at $43.56 per tonne, but there is much uncertainty regarding this value. The nature of climate risks is such that the costs of climate change (and thus of each incremental tonne of GHG emissions) might in fact be much higher. Even if such an outcome has a lower probability, the very high potential costs means that this risk could be significant. To account for this costly "tail risk," ECCC estimates a value of $179.18 per tonne.

Note also that the SCC is likely to increase over time; as the concentration of atmospheric GHGs rises, the cost to society of one *additional* tonne of emissions rises as well. ECCC's central estimate for 2050 is $80 per tonne, compared with approximately $45 today.

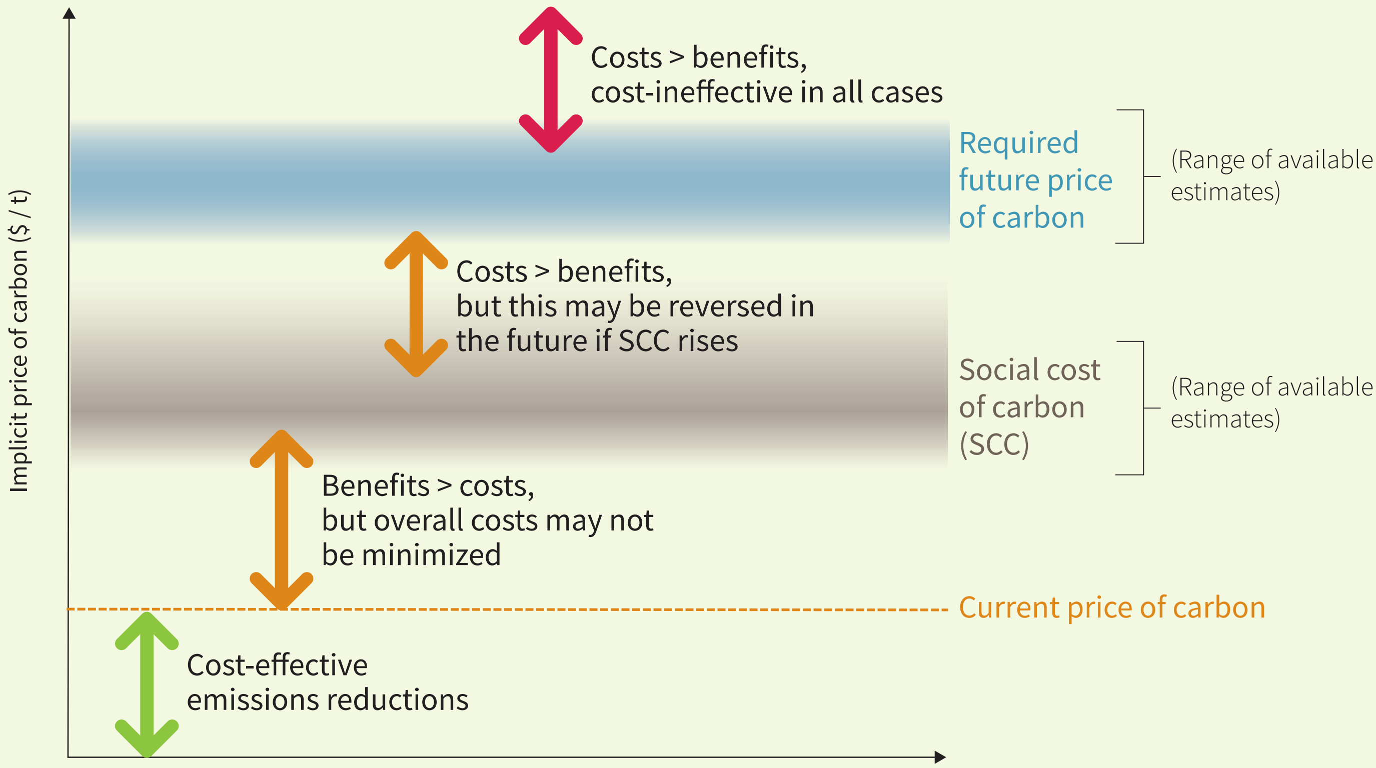
3. Required future carbon prices. If the long-run policy objective is to achieve deep future emissions reductions, the long-run value of the price of carbon may also be a relevant, though uncertain, benchmark.

For Canada to meet its 2030 targets, carbon prices will need to rise significantly. Sawyer and Bataille (2016), for example, estimate that carbon prices would need to reach $150 per tonne to achieve Canada's 2030 target. Jaccard et al. (2016) estimate that a price of $200 is required to achieve the same target. Technological change, using complementary policies, or even purchasing international offsets could reduce this number, but the required future price of carbon is almost certainly higher than the current price, and considerably so. As a result, a policy with a high implicit carbon price may be misaligned with the current explicit carbon price, but consistent with the required future price. In other words, a complementary policy may not be cost-effective today, compared with the explicit carbon price, but may become more cost-effective in the future.

There are arguments for and against each of the benchmarks; there is no single and accepted litmus test for determining the cost-effectiveness of a policy. We recognize that the benchmarks may not be precise: both the future price of carbon and the SCC are uncertain, and indeed may overlap. And further, both the benchmarks and the implicit price of carbon for a given policy can change over time. Still, considering all three benchmarks provides useful context. This is the approach we take in Section 5, where we evaluate the cost-effectiveness of three specific policies.

[29] For more information on how the SCC is estimated, see Appendix B.

Figure 8: Benchmarking implicit carbon prices



The extent to which a policy is cost-effective depends on how its implicit carbon price compares with key benchmarks, including 1) the current, explicit price of carbon (i.e., the rate of a carbon tax, or market price of permits in a cap-and-trade system); 2) the SCC; and 3) the carbon price required in the future to achieve necessary emissions reductions. As there is uncertainty associated with available estimates for the last two benchmarks, these have been signified by the grey and blue shaded areas rather than a line. Note: This figure is not to scale.

Figure 8 provides an overview of these three benchmarks and their implications for assessing the cost-effectiveness of a complementary climate policy.

The three benchmarks lead to four potential ranges into which a given policy might fall, based on its implicit carbon price. We describe each in turn, moving from the bottom of the figure to the top.

The first category is straightforward: A policy with an implicit carbon price below the current explicit carbon price is cost-effective in all cases. The policy drives emissions reductions that are *less costly*, relative to all three benchmarks. Policymakers should embrace these policies, especially if they can drive significant emissions reductions.

A policy that exceeds the explicit carbon price but is less than the *current* SCC represents a more nuanced case. The policy has benefits that exceed its costs, since the cost of its emissions mitigation is more than offset by the benefit that comes in the form of the avoided social costs of those emissions. In this sense, it is unambiguously worthwhile. However, while this policy may pass a cost–benefit test *on its own*, it may be undermining the cost-effectiveness of the climate policy *package*. Uniform carbon prices—across both explicit and implicit prices—ensure that overall mitigation is cost-effective. An implicit price higher than the explicit price suggests that the policy is misaligned with the carbon pricing policy. More cost-effective emissions reductions could be achieved with a more stringent carbon price, instead of the proposed policy (we discuss the cost-effectiveness of the climate policy package further in Section 6). In cases where it is not possible to raise the carbon price, perhaps owing to political constraints, policymakers might prefer complementary policies with implicit carbon prices in this range as a "second best" (Kaufman et al., 2016). However, these higher-cost policies can also present political risks should firms and households come to recognize the implications of the higher costs.

The third range is the case in which a policy's implicit carbon price exceeds the current SCC. Here, the policy's costs exceed its benefits; emissions reductions are costlier than the benefits gained by avoiding those emissions. However, if the implicit price is less than the expected *future* SCC, then the mitigation it delivers, while not cost-effective *now*, could become cost-effective later. This range is especially relevant in the context of achieving deep future reductions or avoiding lock-in of certain types of emissions from long-lived infrastructure. While the policy has high costs now, it may be a *forward-looking* policy that is consistent with what will be considered cost-effective in the future. This case illustrates how trade-offs between effectiveness and cost-effectiveness can complicate the evaluation of policy.

At the high end, a policy with an implicit carbon price above *both* the SCC *and* the future carbon price is considered cost-*in*effective in all cases. Policies in this range are more expensive than alternatives, and likely always will be. Policymakers will be hard pressed to justify these policies on economic grounds.

Benchmarking is a critical step, but is not enough to determine whether a policy is complementary to carbon pricing. The final step of the framework integrates qualitative and quantitative findings to inform a judgment about a given policy.

STEP 5

5 Assess complementarity

The final step in the process is to assess the extent to which a policy is a genuine complement to carbon pricing. This evaluation draws on both qualitative and quantitative evidence on the effectiveness and cost-effectiveness of a particular policy. The results from the qualitative analysis are used to *interpret* the results of the quantitative analysis.

In many cases, policies will present trade-offs: one might reduce many emissions, but at high cost; another might have low cost, but only a limited impact on GHG emissions. In the remainder of this report, we explore how policymakers can move forward with decisions about the best mix of policies given these trade-offs. Before addressing such policy packages, however, we apply our evaluation framework to three illustrative case studies.

5 ILLUSTRATIVE CASE STUDIES

In this section, we consider three case studies in which we apply our framework to the evaluation of Canadian climate policies. We assess the three following policies: 1) federal regulation of oil and gas methane emissions; 2) electric vehicle subsidies in Quebec; and 3) Alberta's phase-out of coal-fired electricity generation. The case studies offer examples of policies that, respectively, fill gaps in carbon pricing's coverage, boost the signal from carbon pricing, and offer non-GHG co-benefits. Each was implemented (or will soon be implemented) in addition to a carbon price.

The case studies are presented using the five steps outlined in Section 4's analytical framework. We qualitatively describe a policy's key characteristics and assess its expected performance. We quantify its expected GHG reductions and costs, and compare its implicit carbon price against relevant benchmarks. Finally, we assess its overall complementarity to carbon pricing, discussing the implications of its complementarity type, policy interactions, and design features.

Applying the framework can be complex. A different analytical approach is used for each of the case studies to illustrate different methods for estimating GHG reductions and costs.[30] These case studies are not intended to be conclusive—only a comprehensive cost–benefit analysis such as those developed by the federal government in Regulatory Impact Assessment Statements (RIAS) can accurately capture the full range of a policy's expected impacts. Instead, the case studies presented here are merely intended to illustrate the application of the framework and to unpack key factors likely to affect the performance of the specific policies assessed.

Our approach to calculating a policy's implicit carbon price mirrors that of the social cost per adjusted tonne of CO_2e found in the RIAS of Environment and Climate Change Canada (ECCC). ECCC calculates this figure by subtracting the present value of the sum of all non-GHG benefits from the present value of the costs, and then dividing by the present value of the tonnes of CO_2e (Environment Canada, 2012). Present values are calculated using a 3% social discount rate.

30 For a full description of sources, methods, and assumptions, see Canada's Ecofiscal Commission (2017).

GAP-FILLER CASE STUDY

5.1 FEDERAL REGULATION OF OIL AND GAS METHANE EMISSIONS

On May 27, 2017, the federal government published its proposed regulations for methane emissions in the oil and gas sector (ECCC, 2017). The policy aims to reduce the oil and gas sector's methane emissions by 40% to 45% below 2012 levels by 2025 (ECCC, 2017). Federal regulations for methane emissions reductions will be phased in over time—the first requirements will address leak detection and repair, well completion, and compressors. They will come into force in 2020. Additional requirements covering facility production venting and pneumatic devices will come into force in 2023 (ECCC, 2016c).

While the policy will apply nationally, British Columbia, Alberta, and Saskatchewan will be disproportionately affected because of their large oil and gas sectors (the regulation is not expected to significantly affect offshore oil and gas). The three provinces each have their own planned or existing measures covering methane emissions from oil and gas, but typically focus only on emissions from venting and flaring. The federal regulations mirror the proposed timeline and stringency of planned methane regulations in Alberta. The federal government has indicated that, should they wish, affected provinces will be able to pursue equivalency agreements for the regulation (ECCC, 2017).

QUALITATIVE

1 Key policy characteristics

Table 6 breaks down the policy's key characteristics, across each of the three key considerations of the framework—rationale, interactions, and design features.

Table 6: Key characteristics of federal policy on methane emissions in the oil and gas sector

Considerations	Description	
What is the rationale for the policy?	• The policy is a **gap-filler**: methane emissions from oil and gas often do not have a point source and can be difficult to measure and price. As a result, they are not covered under provincial carbon pricing policies.	
How does the policy interact with other policies?	• There are no direct interactions with carbon pricing, since regulated emissions are not covered by a cap-and-trade system or a carbon tax. • The policy overlaps with provincial policies but is expected to be broader in coverage; where there is overlap, it is expected to be roughly consistent with their targets and requirements. • If offset protocols in carbon pricing instruments included actions to mitigate methane emissions in the oil and gas sector, policy interactions could occur.	
What are the key design features of the policy?	Design features	
	Stringency	• Reducing methane emissions by nearly half suggests that the policy is fairly stringent. • The delay in the start time of the regulation (relative to the original proposal) will not affect the emissions reductions in 2025, but will lower *cumulative* emissions reductions over that period.
	Coverage	• The policy covers all methane emissions from oil and gas production, and is therefore broad in its coverage.
	Flexibility	• The policy does not allow compliance trading across firms, making it inflexible across agents. • The delay in the start time of the regulation provides firms with some flexibility across time to achieve the required emissions reductions.
	Predictability	• Emissions sources and processes to be covered by regulations have been clearly disclosed, improving predictability. • Providing no indication of post-2025 requirements undermines long-term predictability.
	Governance	• The policy contains no mechanisms for review or recalibration outside of the normal Treasury Board Secretariat guidelines.

QUALITATIVE

2 Expected performance

The policy's expected performance in terms of effectiveness at reducing GHG emissions and cost-effectiveness is shown in Table 7.

Table 7: Expected performance of federal regulations on methane emissions in the oil and gas sector

Objectives	Factors that help	Factors that hinder
Effectiveness	• As a gap-filler that does not interact with carbon pricing, the policy will likely be effective in reducing additional GHG emissions. • Clear communication of the degree of reduction expected from the sector will improve effectiveness, since firms may choose to implement methane-reducing technologies during their regular stock turnover while awaiting details.	• The lack of a mechanism for recalibrating policy stringency may limit opportunities for even deeper emissions reductions. • Weakening the policy's interim requirements (by delaying the implementation timetable for the regulation) will lead to fewer cumulative emissions reductions.
Cost-effectiveness	• Predictability helps improve cost-effectiveness by helping firms avoid misallocating their capital in advance of the regulation.	• The lack of a compliance trading mechanism for firms could increase overall compliance costs.

QUANTITATIVE

3 Emissions reductions and costs

We surveyed existing analyses and literature to quantify the emissions reductions and costs likely to result from the federal policy. ECCC modelling results (ECCC, 2017) are used to define the expected emissions reductions and costs.

Table 8: Expected emission reductions and costs resulting from federal policy on methane emissions in the oil and gas sector

Variable	Estimate	Description
Emissions reductions	**21 Mt CO_2e in year 2025**	Owing to the use of a historical benchmark year to define policy stringency and possible variations in the level of future oil and gas production, the specific level of emissions reductions expected for the policy is uncertain. ECCC estimates mitigation of 21 Mt CO_2e in the year 2025. It estimates cumulative GHG mitigation of 282 Mt CO_2e between 2018 and 2035.
Costs	**\$13/tonne CO_2e**	Because of the opportunity to realize returns on conserved gas, some mitigation that occurs under the regulation may in fact offer a net return to implementing firms in the oil and gas sector. Most, however, is expected to come at a net cost (ICF, 2015). On average, ECCC (ECCC, 2017) estimates the cost of mitigation under the regulation to be approximately \$13/tonne CO_2e.*

*This \$13/tonne CO_2e estimate differs from the \$10/tonne CO_2e estimate seen in ECCC (2017) because it adjusts costs to 2017 dollars and discounts future GHG mitigation using a social discount rate of 3%. This adjustment makes the estimate methodologically consistent with those found in the other case studies.

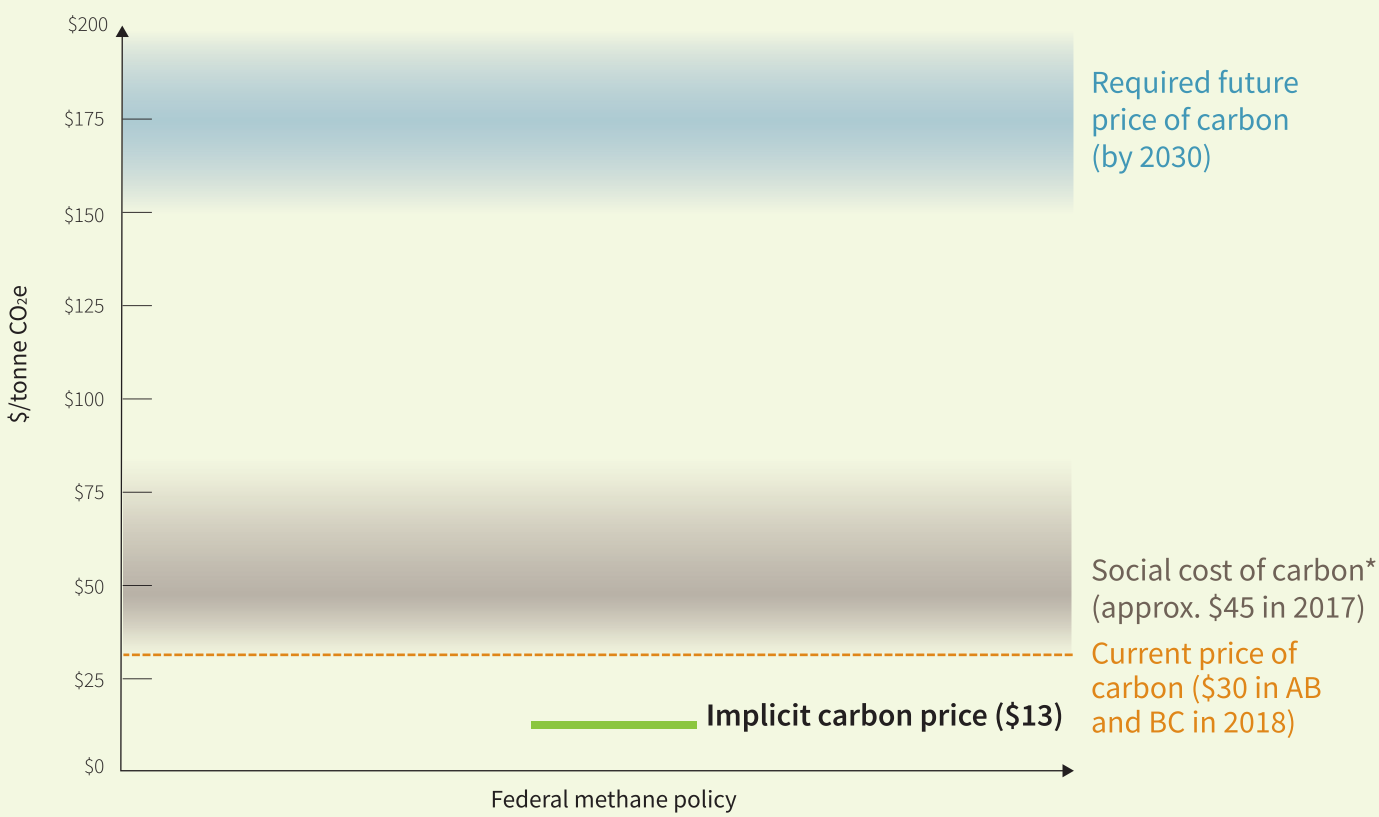
QUANTITATIVE

4 Benchmarking performance

Effectiveness: The mitigation expected as a result of the regulation—21 Mt CO_2e in 2025—is substantial, at nearly half the sector's 2012 methane emissions. Mitigation will also occur in advance of year 2025. ECCC (2017) estimates the cumulative GHG mitigation of the policy to be 282 Mt CO_2e between 2018 and 2035. Further, some mitigation may also take place in advance of the regulation's requirements, as firms take pre-emptive action to coincide with regular stock turnover.

Cost-effectiveness: As illustrated in Table 8, the policy's implicit carbon price of $13 per tonne CO_2e falls below all available benchmarks for cost-effectiveness. This suggests that the policy can be expected to deliver cost-effective GHG mitigation.

Figure 9: Benchmarking the implicit carbon price of federal policy on methane emissions in the oil and gas sector



Even under conservative cost estimates, proposed methane regulations appear to be cost-effective relative to all three benchmarks. As there is uncertainty associated with available estimates for the top two benchmarks, these have been signified by the grey and blue shaded areas rather than a line.

*Given the different global warming potential of methane, an alternative benchmark here could be the *social cost of methane* (Marten & Newbold, 2011).

5 Assessment of complementarity

Regulation of methane emissions in the oil and gas sector is a gap-filling policy. It covers emissions not covered by carbon pricing, so has a strong rationale. And, as illustrated in Figure 9, federal regulations are expected to offer significant mitigation at reasonable cost. Therefore, broadly speaking, the policy can be expected to be genuinely complementary to carbon pricing policies. However, the decision to weaken the policy's implementation timetable relative to what was originally proposed reduces the policy's cumulative GHG mitigation.

Ideally, the regulation might include a flexibility mechanism that allows compliance trading, since abatement costs will be heterogeneous across firms. The lack of such a mechanism may increase costs, reducing cost-effectiveness.

The policy does not contain any provision for policy review and calibration outside of normal Treasury Board Secretariat guidelines. Explicitly incorporating periodic stock-takes that include the possibility of policy recalibration to increase stringency could improve policy effectiveness. However, such a measure might also limit cost-effectiveness by undermining predictability.

Finally, while methane regulations will not interact with carbon pricing policies directly, they could interact with offset systems. Offset protocols are a way of extending carbon pricing's coverage to emissions that cannot be easily measured, but where emissions reductions can be. If offset protocols in provinces affected by the regulation were to include actions that mitigate methane emissions in the oil and gas sector, they would interact with the planned federal regulation on methane. These potential interactions should receive close scrutiny when offset protocols covering the sector are being designed.

In sum, given that the policy's implicit carbon price falls below all relevant benchmarks, the policy is expected to be complementary to carbon pricing; however, specific elements of its design may hinder its effectiveness and cost-effectiveness, and questions remain regarding possible interactions with offset protocols.

SIGNAL-BOOSTER
CASE STUDY

5.2 ELECTRIC VEHICLE SUBSIDIES IN QUEBEC

Under Quebec's Drive Electric (Roulez électrique) program, drivers who purchase or lease fully electric, plug-in hybrid, hybrid, or low-speed electric vehicles (PEVs) are eligible for rebates from the government of up to $8,000 (Government of Quebec, 2016a). The program is funded through the *Fonds vert* (which draws much of its funds from the province's carbon price), with $93 million in total rebates available. The program began in 2012 and will run until 2020, or until available funds are exhausted (Government of Quebec, 2012). Quebec is one of three Canadian provinces that offer significant PEV subsidies: Ontario and British Columbia offer per-vehicle subsidies of $14,000 and $5,000, respectively.

Quebec's vehicle subsidy is part of a larger provincial policy package supporting PEVs. The provincial government is targeting 100,000 registered plug-in vehicles on the road by 2020, and its 2015-2020 Transportation Electrification Plan contains both supply- and demand-side policies to boost PEV sales. (Government of Quebec, 2016a). This case study focuses on the expected impacts of the province's PEV subsidy. However, at times we also discuss the implications of interactions with other PEV support policies in the province, particularly the recently adopted Zero Emission Vehicle (ZEV) mandate.

Under Quebec's ZEV mandate, automakers are required to meet ZEV sales targets set by the provincial government, starting with 2018 models. Every sale or lease of an eligible ZEV earns the manufacturer credits based on the vehicle's range. The greater the range, the more credits the manufacturer earns; each credit reduces the manufacturer's obligations. Firms with excess credits can sell them to other manufacturers that will miss their targets, creating a trading market (Government of Quebec, 2016b).

QUALITATIVE

1 Key policy characteristics

Table 9 describes the key characteristics of Quebec's PEV subsidy for each of the three key considerations of the framework.

Table 9: Key characteristics of Quebec's policy on PEV subsidies

Considerations	Description	
What is the rationale for the policy?	• The policy is a **signal-booster**. • PEV uptake can be impeded by market failures such as incomplete information, network externalities, knowledge spillovers, policy coordination problems, excessive discount rates, and uncertain future carbon prices (Gillingham & Sweeney, 2010; Lin & Greene, 2011; Melton et al., 2016; Struben & Sterman, 2008; Tran et al., 2012; Weber & Rohracher, 2012).[31]	
How does the policy interact with other policies?	• Because they both cover the same transportation sector emissions, the policy interacts with Quebec's cap-and-trade system. • And because they both affect the sales of electric vehicles in the province, the policy will also interact with the province's ZEV mandate.	
What are the key design features of the policy?	Design features	
	Stringency	• The subsidy is relatively generous: the maximum subsidy of $8,000 significantly helps to bridge the cost gap between electric and internal combustion engine vehicles.
	Coverage	• Passenger vehicles form a significant part of transport-sector emissions, which suggests broad policy coverage. • However, the fact that the policy only applies to individuals who voluntarily buy a PEV narrows its effective coverage.
	Flexibility	• The program is flexible across different types of low- or zero-emission vehicle technologies (all-electric, plug-in hybrid, hybrid, etc.). • Because anyone in Quebec can participate and the program is strictly voluntary, it is flexible across both agents and time.
	Predictability	• The policy's eligibility requirements are clearly stated. • The subsidy is available for a clearly articulated and fixed length of time; however, it is not clear from available documentation if it will be renewed or whether the available funds will last until the stated end date.
	Governance	• A mechanism to review the policy in 2017 is built into its design.

[31] These market failures are distinguished from market barriers, such as consumers' reluctance to adopt unfamiliar technologies.

QUALITATIVE

2 Expected performance

The PEV subsidy's expected performance in terms of effectiveness at reducing GHG emissions and cost-effectiveness is shown in Table 10.

Table 10: Expected effectiveness and cost-effectiveness of Quebec's PEV subsidies

Objectives	Factors that help	Factors that hinder
Effectiveness	• If permits in the province's cap-and-trade system continue to sell at the price floor (i.e., if the cap continues to not bind), the policy's GHG mitigation will be additional, supporting policy effectiveness.	• If auction prices rise above the price floor (i.e., if the cap starts to bind), then any GHG mitigation attributable to the PEV subsidy policy will displace mitigation that would have occurred elsewhere under the cap, and the policy will not lead to additional (global) mitigation.
Cost-effectiveness	• The flexibility of the policy's design across technologies, agents, and time improves its expected cost-effectiveness. • In addition, its relatively predictable schedule (notwithstanding questions about possible policy extension) and its built-in review mechanism also help bolster expected cost-effectiveness.	• Raising tax revenue to fund the subsidy will carry an economic cost, which may reduce its cost-effectiveness.

QUANTITATIVE

3 Emissions reductions and costs

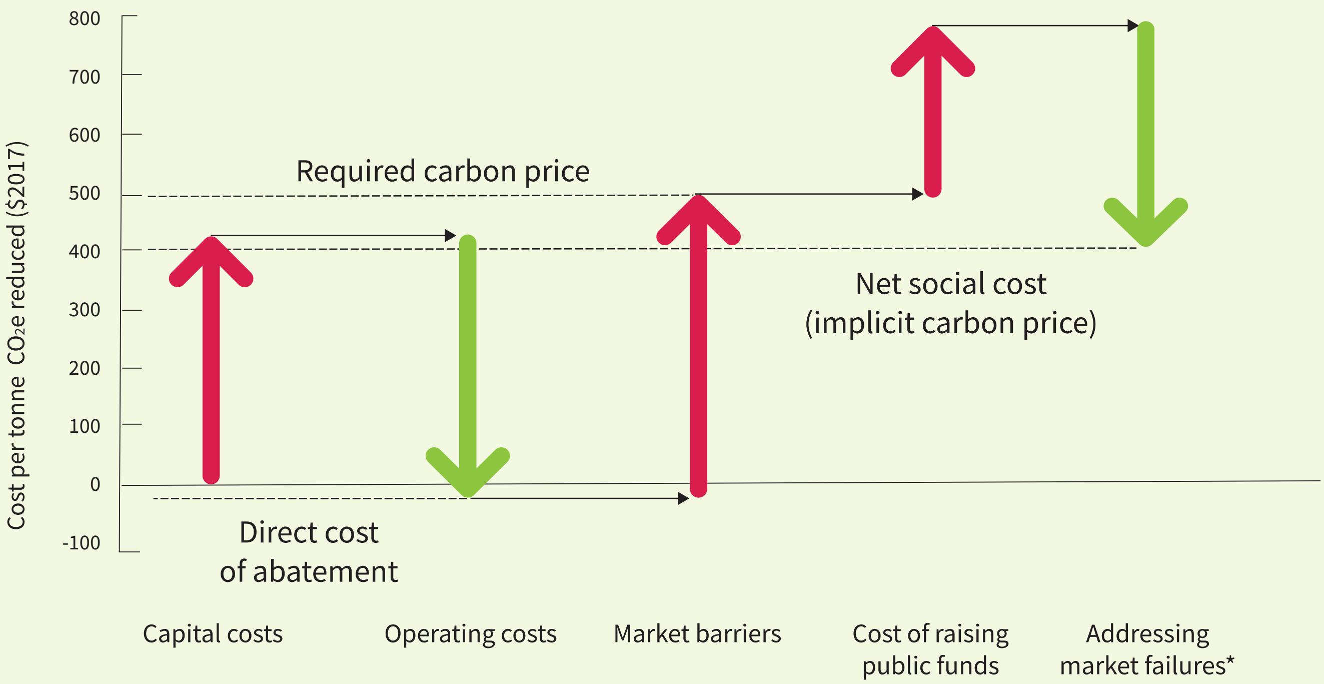
To estimate the GHG reductions and costs expected for Quebec's PEV subsidy policy, the Ecofiscal Commission contracted modelling analysis from Navius Research. Table 11 provides an overview of modelling results, and Figure 10 explains the components in detail. For more information on the model's methodology, assumptions, and parameters, see Canada's Ecofiscal Commission (2017).

Table 11: Expected emissions reductions and costs resulting from Quebec's PEV subsidies

Variable	Estimate	Description
Emissions reductions	**3 Mt CO_2e** by 2030 (cumulative), pending permit market dynamics in the cap-and-trade system	We estimate emissions reductions attributable to Quebec's PEV subsidy by comparing model scenarios in which the subsidy exists with one in which it does not. The province's carbon pricing policy is included in both scenarios. Some consumers who would buy a PEV given the subsidy would instead opt to purchase an internal combustion engine (ICE) vehicle in the absence of that subsidy.[32] By 2030, the cumulative GHG reductions that result from the subsidy policy are estimated to amount to 3 Mt CO_2e.[33] (Estimates of attributable GHG mitigation would vary with alternative modelling assumptions and parameters; see Canada's Ecofiscal Commission [2017] for more information.)
Costs	**$395/tonne CO_2e**	The 3 Mt of mitigation attributable to the PEV policy comes at a high cost—$395/tonne CO_2e based on our modelling analysis. This net social cost expresses the excess cost of PEVs to consumers as compared with an ICE vehicle, the economic cost of providing the subsidy, and the benefit of addressing market failures via the policy. The individual cost elements and their contributions to the net social cost are discussed in Figure 10 and below. Some cost elements have a high degree of uncertainty associated with them. The extent to which some market barriers—which increase the perceived cost of electric vehicles, and are the reason that policy incentives might help to drive adoption— are true market *failures* is particularly uncertain. In light of this uncertainty, estimates of these variables (and the overall social cost of the policy) should be seen as only *indicative* of actual expected costs.

32 Modelling analysis suggests that approximately 3% of PEV buyers in Quebec would have bought a PEV with or without a subsidy. These buyers are said to "free-ride" on the subsidy policy.
33 The policy's net mitigation may in fact be less if the cap-and-trade system's permits begin to sell above the price floor (i.e., if the cap binds).

Figure 10: Breakdown of net social mitigation costs for Quebec's PEV subsidies



This figure decomposes different costs and benefits (each described in the text) associated with Quebec's PEV subsidy program. Each cost (upward arrow) or benefit (downward arrow) is expressed as net costs divided by total emissions reductions expected from the policy (i.e., all costs and benefits are displayed in "per tonne" terms). Both net costs and emissions reductions are incremental: they reflect the difference between a case in which only carbon pricing is implemented and a case in which both carbon pricing and the PEV subsidy are implemented. To better summarize the modelling results, time-series estimates for the cost and benefit variables seen here have been converted to single-point estimates using present value discounting, in line with Environment and Climate Change Canada's approach to calculating policies' social cost per adjusted tonne of CO_2e.

*In the available literature on PEVs, it is difficult to separate the effect of genuine market failures from the larger set of market barriers. Therefore, there is considerable uncertainty associated with our estimate of market failures' expected impact.

Capital costs represent the average additional cost of purchasing a PEV compared with an ICE vehicle. PEVs cost more to purchase than conventional vehicles; therefore, capital costs appear in the figure as a net cost.

Operating costs represent the additional cost of operating a PEV compared with an ICE vehicle over *its lifetime*. As illustrated in the figure, the costs are negative, meaning there are net operating *savings* associated with owning a PEV over its lifetime, given its lower relative fuel costs.

Direct costs of abatement are the sum of capital costs and operating costs. They express the total additional cost of owning a PEV instead of an ICE vehicle, indicating the abatement costs associated with PEV uptake. The modelled *negative* direct cost of abatement suggests that the purchase of an ICE vehicle should offer a net *return* over its lifetime under the province's cap-and-trade system. However, market barriers in the PEV sector (as discussed below) inhibit the uptake of this seemingly cost-effective mitigation action.

Costs of market barriers reflect non-financial factors that affect consumers' preferences. They are important in the PEV sector: Since PEVs are a new technology, some consumers may be unaware of the net lifetime savings they can offer. Consumers may also perceive the costs of PEVs to be higher as a result of inconveniences such as limited charging infrastructure or the required charging time. This element is estimated based on empirical findings regarding how consumers actually behave when considering purchasing PEVs. Importantly, it captures both the market *barriers* (range anxiety, consumer preferences, etc.) and the genuine market *failures* (incomplete information, uncertain future carbon prices, etc.) that may be limiting PEV uptake. While the analysis is based on survey data that captures driver preferences, the extent to which these preferences are driven by market barriers or market failures is highly uncertain.

Required carbon price indicates the cost of mitigating GHG emissions by purchasing PEVs as *perceived* by potential PEV consumers. It combines their direct capital and operating costs (relative to an ICE vehicle), as well as both the real and perceived *additional* costs that they anticipate when considering purchasing a PEV. It implies the level of carbon price that would have been necessary (over and above the existing explicit carbon price) to overcome the market barriers that are impeding consumers' wide-scale adoption of PEVs.

Cost of raising public funds reflects the economic costs of the government subsidy for the purchase of PEVs. The subsidy is largely funded by cap-and-trade permit auction revenue via the *Fonds vert*. Raising funds through most forms of taxation adds distortions to the economy and has an economic cost. As illustrated in the figure, the economic costs of raising public funds are considerable.[34] These costs are measured using an estimated marginal cost of public funds for revenue collected from Quebec's cap-and-trade system.

Benefits of addressing market failures are the social benefits of overcoming true market failures. The market barriers variable described above signals the effect that features of the PEV market can have on how consumers perceive PEVs' costs. For example, buyers might have *perceived* higher costs owing to a lack of information about new technologies, such as the range and reliability of batteries. If this problem is a true market failure, once the vehicle is purchased as a result of the subsidy policy, the buyer will realize he or she overestimated these costs. Furthermore, other potential buyers may have fewer misgivings about PEVs the more they see others buying them (Mau et al., 2008). This variable estimates the benefit that the subsidy offers with respect to its effect on reducing market failures—namely, its "signal-boosting" effect.

Net social cost is an estimate of the policy's net costs to society. It is estimated as the total of all previous cost elements. These social costs reflect the policy's *implicit carbon price*. The value seen in the figure only *estimates* the policy's true social cost: other, non-modelled costs and benefits might change the results shown above; for example, health benefits from reduced air pollution as a result of increased PEV use, or the benefits of knowledge spillovers in the PEV sector. Because of the small size of Quebec's PEV sector, these effects are expected to be small and uncertain, and so are not modelled here. If included, they would marginally lower the social costs that we estimate.

[34] Owing to associated uncertainty, these costs are difficult to estimate with precision. They should be seen as *indicative* of the expected cost of raising public funds.

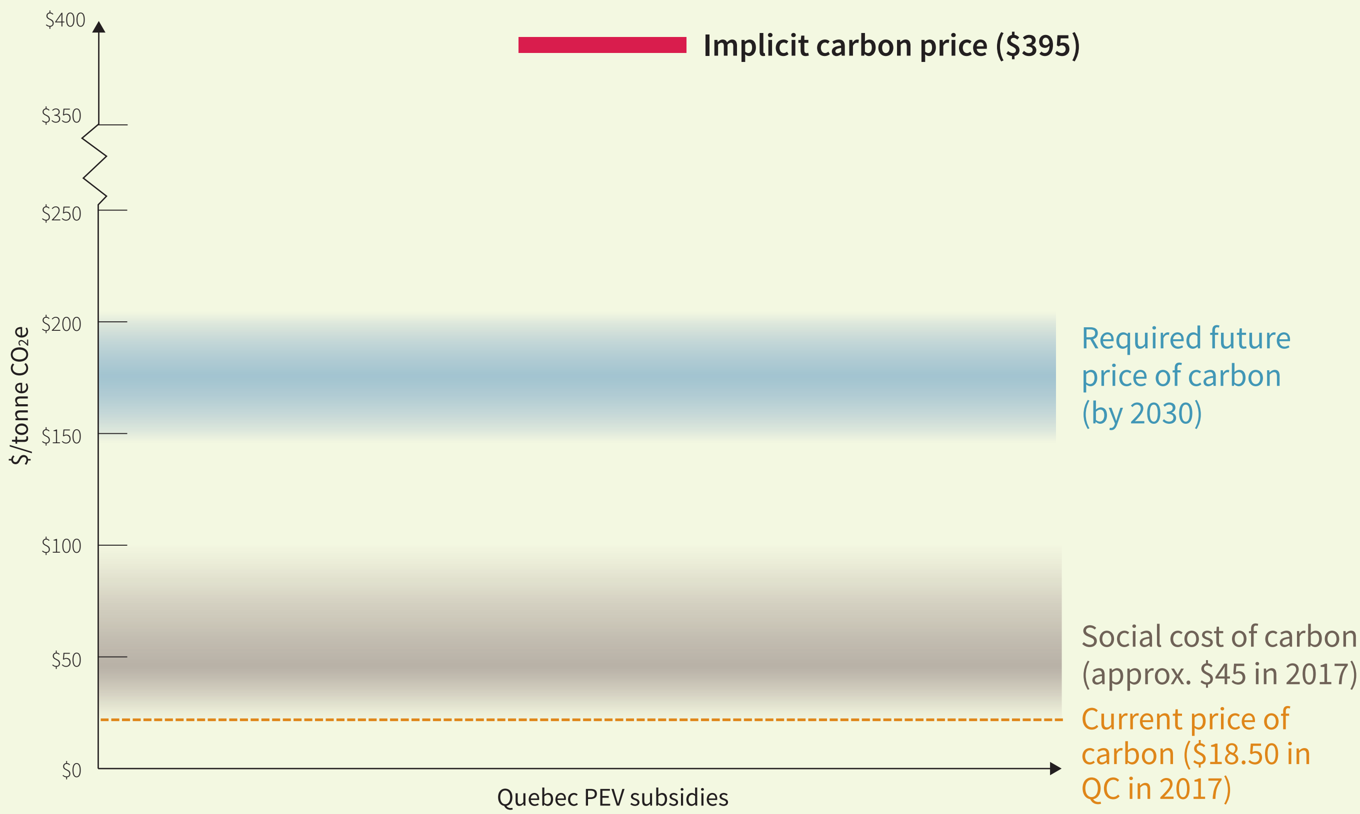
QUANTITATIVE

4 Benchmarking performance

Effectiveness: Emissions reductions attributable to the policy are fairly small. The cumulative mitigation of 3 Mt CO_2e by 2030 represents a very small share of Quebec's passenger transport emissions, which were 17 Mt CO_2e annually as of 2014. Further, pending interactions with the province's cap-and-trade scheme, the policy's net attributable mitigation may be even lower.

Cost-effectiveness: The mitigation that the policy directly achieves also comes at a very high cost. As seen in Figure 11, the policy's implicit carbon price of $395/tonne significantly exceeds all available benchmarks for cost-effectiveness.

Figure 11: Benchmarking the implicit carbon price of Quebec's PEV subsidies



Based on our analysis, Quebec PEV subsidies have a high cost per tonne of emissions reduced. They are cost-ineffective relative to all three benchmarks, largely as a result of the economic costs of funding the subsidy. As there is uncertainty associated with available estimates for two of the benchmarks, these have been signified by the grey and blue shaded areas rather than a line.

5 Assessment of complementarity

PEVs are expected to play a key role in the decarbonization of the transportation sector and the larger economy (Bahn et al., 2013; Sykes, 2016; Williams et al., 2012). Owing to market failures in the PEV sector, carbon pricing alone may be slow to deliver significant and timely uptake and development of PEVs, and therefore there are arguments for using "signal-boosting" policy.[35]

Both demand-side and supply-side policies are available to support PEVs, and many observers note that a package of policies is likely needed to bring about significant uptake (Axsen et al., forthcoming). Available demand-side measures include purchase subsidies, public investment in recharging infrastructure, or non-financial incentives such as high-occupancy vehicle lane access and free parking. Possible supply-side measures include ZEV mandates, low-carbon fuel standards, and subsidies for R&D (Axsen et al., forthcoming). As discussed above, our research shows that PEV subsidies appear to be a high-cost policy option for supporting PEVs, largely because of the high economic cost of raising public funds.[36] In addition, fairness implications might also be important, since significant amounts of public funds are being spent on providing support that disproportionally benefits wealthier households (Irvine, 2017).

As noted above, Quebec is not the only province supporting PEV uptake with subsidies; British Columbia and Ontario also offer subsidies toward the purchase of PEVs. In B.C., PEV subsidies would also likely come at a high mitigation cost, but because they interact with a carbon tax, they would be expected to drive additional GHG reductions in all cases. As in Quebec, Ontario's PEV subsidies would interact with its cap-and-trade system, so its policy's interactions with carbon pricing are likely to have similar implications for effectiveness. However, with respect to cost-effectiveness, the analysis is complicated by the fact that Ontario also has a vehicle-manufacturing sector, which the PEV subsidies may also be intended to support (i.e., as a non-GHG co-benefit).

Although not modelled, PEV subsidy policies might offer co-benefits with respect to long-term emissions reductions. Adoption of passenger PEVs may serve a technology demonstration function, and help bring about wider transformation of the transportation sector (electrifying trucks, buses, etc.), and industrial electrification in general. However, owing to their apparent high costs, the merits of—and rationale for—PEV subsidies (both in general and as part of a broader policy package for PEVs) should be examined carefully.

Notably, policy interactions with Quebec's ZEV mandate (and other policies), which are also not modelled here, might improve the case for providing PEV subsidies. However, they could very well *undermine* cost-effectiveness by adding costs without improving uptake, since the two policies, to a certain degree, substitute for one another.[37] The degree of PEV uptake that each drives will be a function of their respective stringency, and there will inevitably be overlap in the level of electric vehicle uptake that each brings about. If electric vehicle uptake after the subsidy policy does not exceed the amount of PEVs required under the mandate, there would be no additionality from the policy's subsidies for electric vehicles, and its estimated cost-effectiveness would worsen. The implications of interactions between the two policies should be further explored.

Overall, more research and evidence is required before Quebec's PEV subsidies can be justified as a complementary climate policy. When the policy comes up for review this year, policymakers should think carefully about whether to renew it after its 2020 expiration—particularly in light of its potential interactions with the province's ZEV mandate. A regulatory instrument similar to California's (see Jaccard, 2016) that expanded the ZEV mandate to cover hybrid vehicles could potentially offer a lower-cost policy approach.[38]

[35] Wide deployment of PEVs would also provide co-benefits, such as reduced air pollution and associated impacts on human health. Therefore, at sufficient scale, PEV support could also be a benefit-expanding policy.

[36] Free-ridership also plays a role, given that some of these funds are paid to consumers who would have bought a PEV at a lower subsidy, or even in the absence of the subsidy. Approximately 3% of subsidy recipients are estimated to free-ride in such a fashion.

[37] Differences in their coverage mean that they are not perfect substitutes: both policies cover electric vehicles, but the subsidy policy covers hybrid and plug-in hybrid vehicles, while the ZEV mandate does not.

[38] Such an approach, however, would raise challenging questions around incidence: while the cost of PEV subsidies falls to governments, the cost of a mandate would fall to some degree on vehicle manufacturers and distributors, who may push back on regulations.

BENEFIT-EXPANDER CASE STUDY

5.3 PHASING OUT COAL-FIRED ELECTRICITY GENERATION IN ALBERTA

The Government of Alberta's current Climate Change Leadership Plan calls for the phase-out of emissions from coal-fired electricity generation by 2030. Alberta has 18 coal plants in total, responsible for 38% of the province's electricity generating capacity and 62% of its electricity generation (AESO, 2017). The planned regulation will apply to six coal-fired plants that are scheduled for decommissioning later than 2030. The remaining 12 plants will retire before 2030 under the 2012 federal regulations on coal-fired electricity, which call for plants to be retrofitted or decommissioned at their "end of useful life" (usually 50 years, with milestones in 2019 and 2029) (Environment Canada, 2012; Government of Alberta, 2016). To compensate firms for this policy change, the Alberta government negotiated a payout of approximately $1.3 billion, to be paid in annual instalments between 2017 and 2030.

Alberta is not the first province to phase out coal. In 2003, Ontario committed to eliminate all of its coal-fired electricity generation and closed the last of its five coal-fired generating stations in 2014. The phase-out of coal in Ontario is estimated to have abated 34 Mt CO_2e of annual emissions—the most significant mitigation action in Canada to date (Harris et al., 2015). Because Ontario phased out coal *in advance* of implementing its cap-and-trade system, its policy, at the time, substituted for carbon pricing, rather than complementing it. Alberta, on the other hand, is pursuing its coal phase-out in parallel with carbon pricing, which is why we have chosen to focus on it in this case study.

In Alberta, the sector's emissions currently fall under the Specified Gas Emitters Regulation, but as of 2018, they will be regulated under the province's planned Carbon Competitiveness Regulation (CCR), its carbon pricing policy for large final emitters. In addition, the province has also set a target to source 30% of its total electricity generation from renewables by 2030. To help bring about this shift toward renewables, the government is implementing the Renewable Electricity Program (REP), which will provide credits toward the production of renewable electricity.

Note that the details of the CCR are not yet final. As a result, this case study provides only an illustrative assessment of *potential* policy impacts in Alberta. It identifies the key factors relevant for assessing complementarity, but the specifics of the CCR policy will be important for a more definitive evaluation.

1 Key policy characteristics

Table 12 breaks down the key characteristics of the phase-out across each of the three key considerations—complementarity type, interactions, and design features.

Table 12: Key characteristics of Alberta's coal phase-out policy

<table>
<tr><th>Considerations</th><th colspan="2">Description</th></tr>
<tr><td>What is the rationale for the policy?</td><td colspan="2">• The policy is a benefit-expander: the phase-out of coal will reduce air pollution, a result associated with significant human health benefits (Environment Canada, 2012; Anderson et al., 2013).</td></tr>
<tr><td>How does the policy interact with other policies?</td><td colspan="2">• Because they both cover emissions from the electricity sector, the policy will interact with Alberta's planned carbon tax policy for large final emitters—the CCR.
• The REP will affect incentives and outcomes in the electricity sector, so policy interactions with this program may also occur.</td></tr>
<tr><td rowspan="6">What are the key design features of the policy?</td><td colspan="2">Design features</td></tr>
<tr><td>Stringency</td><td>• The phase-out requirements are significantly more stringent than the 2012 federal regulations on coal-fired electricity, which mandate closure of coal plants at their "end of useful life";[39] however, at the same time, Alberta's phase-out allows affected plants to continue operating until 2030.</td></tr>
<tr><td>Coverage</td><td>• The policy affects all coal-fired electricity in the province (a significant source of provincial emissions), so is broad in its coverage.</td></tr>
<tr><td>Flexibility</td><td>• The phase-out policy will be flexible across technologies if it allows coal plants to continue to operate if they can reduce their emissions to being equivalent to natural gas-fired electricity, or another relevant benchmark.</td></tr>
<tr><td>Predictability</td><td>• The policy has a definitive deadline of 2030; however, it is unclear whether some of the regulated plants will go offline before 2030.</td></tr>
<tr><td>Governance</td><td>• Governance mechanisms are not yet clear, since some policy details are still forthcoming.</td></tr>
</table>

[39] The federal government has also proposed a federal coal phase-out policy that would be more stringent than this—requiring the phase-out of all coal-fired electricity by December 31, 2029 (unless provinces reach an equivalency agreement with the federal government) (Government of Canada, 2016b). Because this phase-out timeline is roughly consistent with Alberta's earlier-announced policy (which calls for a phase-out by December 31, 2030), we restrict our focus to Alberta's phase-out policy, rather than the proposed federal one.

QUALITATIVE

2 Expected performance

The expected performance of Alberta's coal phase-out policy in terms of effectiveness at reducing GHG emissions and cost-effectiveness is shown in Table 13.

Table 13: Expected effectiveness and cost-effectiveness of Alberta's coal phase-out

Objectives	Factors that help	Factors that hinder
Effectiveness	• Because the CCR involves a carbon tax rather than a cap-and-trade system, interactions with it will not undermine the effectiveness of the coal phase-out. • The phase-out has a relatively aggressive timeline, and the six affected coal plants have large annual emissions—approximately 18 Mt CO_2e per year.	• Some of this coal phase-out may have occurred under the CCR policy alone, which would hinder its effectiveness.
Cost-effectiveness	• Phasing out coal can be expected to offer significant health co-benefits, thus offsetting some costs. • While some design details are still pending, the Alberta government has provided clear signals as to how the phase-out will operate.	• The planned payout to coal producers is funded from the province's carbon tax revenue. As always, expenditures have opportunity costs: using money in this way means it cannot be used for other objectives (e.g., reducing existing taxes).

QUANTITATIVE

3 Emissions reductions and costs

To estimate the GHG reductions and costs of Alberta's coal phase-out, the Ecofiscal Commission developed a model of electricity supply costs in Alberta. For more information on this model's methodology, assumptions, and parameters, see Canada's Ecofiscal Commission (2017).

In this case study, questions of interaction are critical—that is, what does the coal phase-out policy accomplish that the CCR would not? Because of the complexities of these interactions, we discuss the reference case and policy scenarios in greater detail than in the two previous case studies.

Reference case scenario: The model's reference case quantifies the effect that Alberta's planned CCR is expected to have on generation from the six coal plants that will be affected by the coal phase-out. It models how firms would react to the CCR policy by quantifying their expected costs across four possible responses: 1) continuing to operate coal plants after 2030 at their historical average capacity factor;[40] 2) continuing to operate plants but reducing their capacity factor; 3) shuttering the plants and building gas-fired generation capacity to replace the lost coal generation; and 4) shuttering the coal plants and building a mix of gas-fired and renewable electricity generation capacity, in line with the province's target of 30% of generation being renewable by 2030.

Modelling results indicate that firms' most likely response to the CCR policy would be to continue to operate coal plants beyond 2030, but at a much-reduced capacity factor.[41] This response is likely the least-cost alternative from their perspective. It suggests that while a coal phase-out driven by the CCR alone is unlikely, a significant phase-*down* would likely have occurred. In terms of the generation that would be lost when coal was phased down, modelling analysis indicates that firms could be expected to build new gas-fired capacity in its place (rather than a mix of gas and renewables), since they would perceive gas as the least-cost mode

[40] A plant's capacity factor is its total annual generation divided by its total annual *potential* generation.

[41] The precise capacity factor they would choose is uncertain, since it depends on how the sector evolves between now and 2030, and how the overall market will function once Alberta shifts from an energy-only market to a capacity market for electricity (for more information on Alberta's planned capacity market for electricity, see Shaffer [2016]). Each possible level of output would imply different variable costs, and firms would operate at whatever capacity factor allowed them to both recover costs and maximize profits. If no economical capacity factor existed, electricity production from coal would no longer be economical, and all coal plants would close in the reference case. This possibility is discussed in Table 14.

of generation.[42] Therefore, the reference case scenario is defined by a phase-*down* of coal generation, and the generation shortfall being met with the construction of new gas plants.

Policy scenario: Under the policy scenario, the six coal plants close in 2030, instead of continuing to operate at a reduced capacity, as modelled in the reference case. Our analysis suggests that the sector will perceive gas as the least-cost mode of generation and, as a result, new gas plants will be built to replace lost coal-fired generation. Table 14 summarizes the coal phase-out policy's expected GHG reductions and costs, according to modelled estimates.

Table 14: Expected emissions reductions and costs resulting from Alberta's coal phase-out

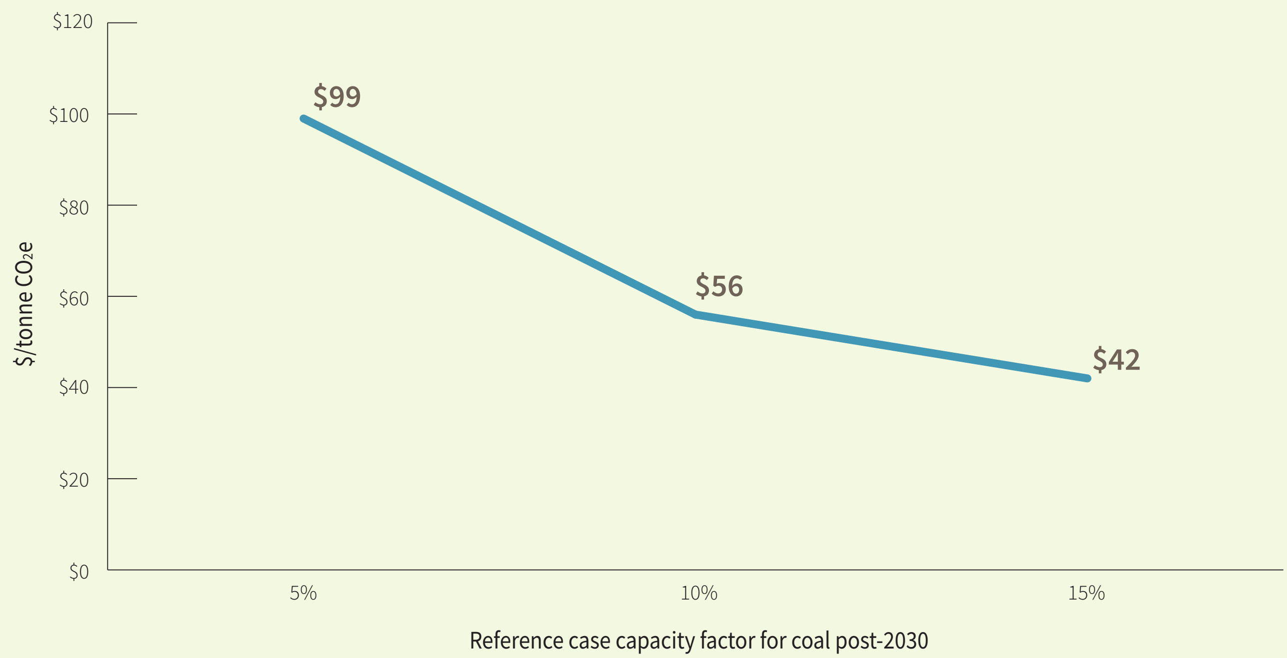
Variable	Estimate	Description
Emissions reductions	**0-49 Mt CO_2e** 2030-2061 (cumulative)	Using gas in place of the coal generation that would have continued in the reference case post-2030 is associated with GHG reductions. However, the level of mitigation attributable to the coal phase-out policy depends on the output that coal plants would have continued to produce under the CCR policy alone, which is uncertain. A post-2030 capacity factor of 15% (which is seen as an upper bound) is estimated to cumulatively drive 49 Mt CO_2e of mitigation between 2030 and 2061. Lower capacity factors suggest lesser mitigation. If the coal plants' reduced level of operation was not economical (i.e., if revenues could not cover costs), plants could be expected to shutter in the reference case, which would mean that there would be zero mitigation attributable to the coal phase-out policy (the lower bound for mitigation estimates).
Costs	**\$42 to \$99 / tonne CO_2e[43]** (costs per tonne are undefined if mitigation equals zero)	The costs attributable to the coal phase-out policy are 1) the cost of building and operating new gas-fired plants to replace lost generation; 2) the cost of raising public funds to fund the payout to coal producers; 3) the lost economic value of the coal plants;[44] and 4) the health benefit of phasing out the phased-down coal generation seen in the reference case. The health benefits are significant: they reduce the policy's expected mitigation costs by approximately \$21/tonne CO_2e. As shown in Figure 12 below, the mitigation cost of the coal phase-out policy depends on the level of output that coal plants would operate at in the reference case. At a 5% capacity factor, we estimate mitigation costs to be \$99/tonne CO_2e. At 15%, they fall to an estimated \$42/tonne CO_2e. If coal operation was not economical at any level of output, coal plants would shutter in the reference case. In this case, the cost of the payout to coal producers would not be associated with any GHG mitigation, and mitigation costs would be undefined (i.e., they would have a zero denominator). The level of costs estimated here is consistent with other studies of the costs of phasing out coal in Canada. In a recent national-level study, modelling by Dolter and Rivers (2017) finds that retiring Alberta's coal-fired capacity and replacing it with wind power and natural gas facilities has an implied marginal abatement cost of \$70-\$80/tonne CO_2e.

[42] It is possible that some lost generation would be replaced by greater generation from existing gas plants (i.e., increases on the intensive margin). However, our case study is focused on long-term dynamics in the electricity sector and assumes that generation shortfalls are met with new capacity (i.e., increases on the extensive margin). We also do not model the possibility of retrofitting coal plants with carbon capture and storage or converting them to biomass or gas. For more on the possibility of biomass conversion, see Rowe et al. (2017).

[43] This is not a comparable calculation to the \$97/tonne cited by the Alberta government, which has a different scope and methodology. The Alberta government figure only considers the direct costs associated with the payout, and does not separate the CCR policy's expected effect from its estimate of the GHG mitigation associated with the phase-out policy.

[44] The payout to coal producers is used to approximate this lost economic value.

Figure 12: Possible mitigation costs under Alberta's coal phase-out policy



This figure shows a sensitivity analysis around our estimates of the costs (per tonne of GHG emissions reduced) of Alberta's coal phase-out. It illustrates that the costs of the policy depend on the capacity at which coal-fired plants would have operated in a scenario that includes carbon pricing under the CCR, but excludes the coal phase-out. The more that carbon pricing would have led to coal plant closure anyway, the higher the estimated incremental costs per tonne of the coal phase-out. Each capacity factor corresponds to a different level of generation costs and total generation. Plants would have continued to operate at the highest operating capacity that allowed them to receive an average price for their total generated power that exceeded their costs and maximized their profits. With a 5% capacity factor, costs are estimated at $149/kWh and annual generation at 1,103 MWh; at 10%, they are estimated at $112/kWh and 2,207 MWh; and at 15%, they are estimated at $99/kWh and 3,310 MWh. (Per-megawatt costs are higher at low capacities, because plants' fixed costs are being spread over a smaller amount of total generation.) The extent to which coal plants would still be run in the reference case scenario (i.e., what capacity factor they would adopt) would depend on what the market for power was like in 2030, which—especially in light of the complexity and uncertainty introduced by the province's planned changes to its electricity market for electricity introduces—is beyond the scope of our analysis.

BENEFIT-EXPANDER CASE STUDY

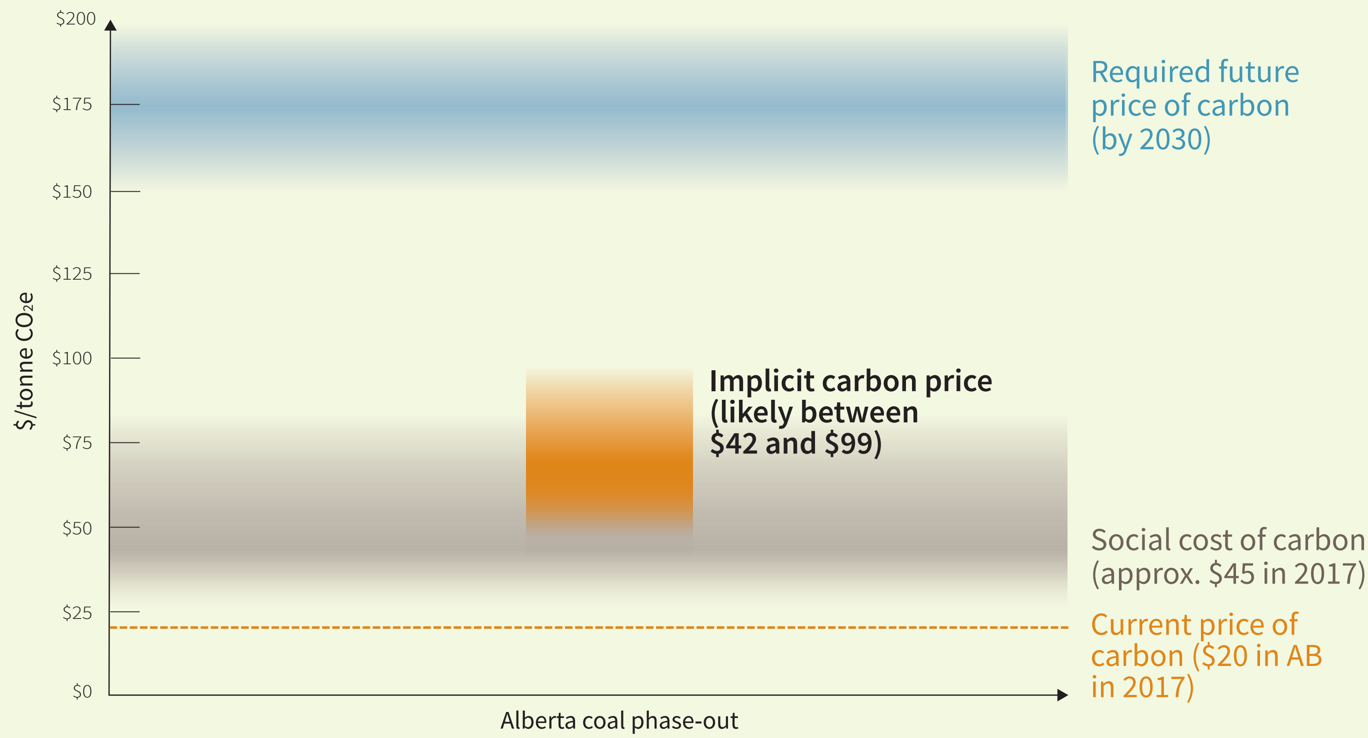
QUANTITATIVE

4 Benchmarking performance

Effectiveness: The effectiveness of the coal phase-out policy depends strongly on the reduced capacity factor that coal plants would have operated at under the CCR policy alone. This uncertainty creates a wide range for estimated GHG mitigation—up to 49 Mt CO_2e of cumulative mitigation by 2061 under a higher capacity factor, and as low as zero if no level of reduced operation was economical, making it difficult to precisely benchmark policy effectiveness.

Cost-effectiveness: The implicit carbon price of the coal phase-out policy falls between available benchmarks: it exceeds Alberta's current price of carbon and (likely) exceeds the social cost of carbon, but it is less than the future price required to meet Canada's emissions targets. Judging it against these benchmarks, the policy's estimated costs are in the mid-range—neither particularly cost-effective nor cost-ineffective.[45] However, selecting the appropriate benchmark for this case study is complicated by the fact that there are dynamics at play: the payout to coal producers is a front-loaded cost, while most of the mitigation and health benefits occur in 2030 and beyond.

Figure 13: Benchmarking the implicit carbon price of Alberta's electricity-sector policies



This figure benchmarks the cost-effectiveness of Alberta's proposed coal phase-out. There is uncertainty in our estimate stemming from the extent to which coal-powered plants would have phased down generation as the result of carbon pricing alone. Our analysis suggests that the implicit carbon price of the phase-out is higher than Alberta's explicit price of carbon, and likely higher than the social cost of carbon. As there is uncertainty associated with available estimates for the top two benchmarks, these have been signified by the grey and blue shaded areas rather than a line.

[45] Assuming that the policy's attributable mitigation is greater than zero. If it is zero, the policy would carry net costs but have no attributable GHG mitigation, making it cost-ineffective

5 Assessment of complementarity

Alberta's CCR policy is expected to drive most of the phase-out of coal in Alberta; the phase-out policy will likely only eliminate the small amount of coal generation that might have continued post-2030. It follows that most of the health co-benefit from the predicted decline in coal use would be attributable to the CCR, and not the phase-out policy. However, because the reduced amount of coal operation seen in the reference case would likely have been concentrated in certain peak days and times, its health impacts during operation would have been notable. As described above, the health co-benefit from the phase-out policy is significant—it causes estimated mitigation costs to fall by approximately $21/tonne CO_2e. Even though the value of these health co-benefits can be difficult to precisely estimate, failing to consider them would have led to an overestimation of the policy's mitigation cost, and exemplifies why it is critical to consider the value of potential co-benefits in evaluations of complementary climate policies.

The coal phase-out policy's implicit carbon price, although uncertain, is consistent with required future carbon prices even at the high end of its range. Given how long-lived generation capacity tends to be, it may make sense to use the eventual, long-term price as the relevant benchmark in this case. Under this benchmark, the policy might be a complementary policy that is slightly forward-looking.

There may also be another, subtle co-benefit objective of the policy in the form of the policy leadership that it signals. A full phase-out of coal in Alberta shows other jurisdictions, both domestically and internationally, that Alberta is serious about GHG mitigation, and it may encourage them to act more boldly in their own climate policies. Further, it may also be intended to signal that the province is not a laggard on climate policy, which may help it secure the greater desired "social licence" for its resources and products. The value of these policy leadership co-benefits is of course very difficult to quantify. Still, these additional factors should be acknowledged in any assessment of the policy's merits.[46]

Box 6 examines some added complexity that comes from the likely interaction between Alberta's planned coal phase-out and the REP also announced for that province.

[46] Another potential co-benefit is that a full, definitive phase-out of coal may encourage the entry of new firms into the electricity market. These firms might otherwise have been reluctant to invest in Alberta if they thought that they would have to compete with coal plants that have sunk capital costs.

Box 6: A deeper look at policy interactions in Alberta's electricity sector

Alberta's planned Renewable Electricity Program (REP) policy, which will provide credits toward the production of renewable electricity, will likely interact with the planned coal phase-out, making policy assessment more complicated.

As an extension to our basic modelling, we also considered the impact of introducing Alberta's REP policy. Our analysis suggests that the incentives it would create for renewable energy production would likely cause firms to see a mix of gas and renewables as the least-cost source of new generation sources, rather than natural gas alone. These incentives would not be sufficient to motivate firms to phase out coal; instead, generators would prefer to continue to operate coal at a reduced capacity factor. However, by shifting the type of replacement generation to a mix of gas and renewables, the REP policy would likely contribute significant GHG mitigation.

In addition, the presence of the REP could actually *lower* the costs of the coal phase-out policy. Because the program is expected (in our model estimates) to deliver mitigation more cost-effectively than the coal phase-out, together they would drive more emissions reductions at a lower overall cost than the coal phase-out alone. Essentially, the program is expected to bolster the case for a coal phase-out, highlighting the importance of considering the effect of policy interactions.

However, there is an important caveat here. The REP policy is only necessary because the province's proposed Carbon Competitiveness Regulation (CCR) would provide little incentive for renewable generation. Under the CCR, emitters would receive output-based allocations (OBAs)—subsidies provided to them on the basis of their level of production—based on a best-in-class reference level for the emissions intensity of production. In the electricity sector, OBAs would be distributed based on "good as best gas"; that is, coal-fired generators would only effectively pay a carbon price on emissions over and above what a gas plant would have generated, and gas plants would pay no carbon tax, or very little. Renewable generators, on the other hand, because they do not pay the carbon tax, would not benefit from OBAs. This would have the effect of putting gas and renewables on an equal basis, and is the reason why an REP policy might be justified.

However, if there were no OBA policy in place and all generation sources paid the full carbon price on all emissions, the incentive for renewables would, according to our modelling results, be sufficient for firms to see a mix of gas and renewables as the least-cost mode of generation. Furthermore, they would likely see coal generation as being so costly that they could be expected to phase out coal generation unilaterally. If no OBA policy were in place in the CCR policy, it appears that neither a REP policy nor a coal phase-out would be necessary. This raises the question of whether OBAs are a useful policy tool for the electricity sector.

OBA policies are likely being used in the electricity sector to address a key market failure: market power. Because there are a limited number of firms in Alberta's electricity sector and limited competition between them, there is a risk that firms will react to the carbon price by using their market power to suppress output and keep prices high, which would raise costs for electricity consumers (Brown et al., 2017; Brown & Olmstead, 2017). By instituting OBAs, this risk can be mitigated (Gersbach & Requate, 2004). But it also forces a reliance on high-cost subsidy and regulatory policies to achieve outcomes that might simply occur under market forces in the absence of an OBA policy. (Indeed, to ensure that the OBAs aren't absorbed as windfall profits and that their value is passed on to consumers as intended, it may even be necessary to further regulate firms.) Furthermore, the policy's short-term benefit in the form of lower electricity costs could carry a long-term cost in the form of the low electricity price discouraging entry by new firms, potentially reinforcing market power problems. It could also reduce incentives to consume less electricity.

It is an open question whether the benefits of Alberta's OBA policy outweigh the costs, and this question should be closely examined as Alberta designs its climate policies focused on the electricity sector.

6 A COHERENT PACKAGE OF CLIMATE POLICIES

The framework in Section 4 and the case studies in Section 5 illustrate how to assess the complementarity of specific policies, whether existing or proposed. We now shift to a more applied context. How can policymakers develop a *package* of policies that work together effectively and cost-effectively? Not surprisingly, the same key considerations for assessing individual policies are relevant for developing a coherent policy package, though in a slightly different way. Building on our previous analysis, this section lays out principles for assembling a package of GHG-related policies.

6.1 IDENTIFYING PRIORITIES FOR COMPLEMENTARY POLICIES

Any number of additional, non-pricing GHG policies can be imagined. But what kinds of policies should be prioritized, and which ones are genuine complements to the carbon price? This is a question of materiality: if the focus is efficiency and cost-effectiveness, the priority should be policies that drive the biggest emissions reductions at the lowest net cost per tonne. Our framework can make this objective more concrete, as we discuss below.

Broad carbon pricing should be the centrepiece of any coherent policy package

Identifying specific policies that can be effective and low-cost is quite challenging. Abatement costs vary from emitter to emitter and change as technologies evolve. This is precisely why a broad, steadily rising carbon price should be the centrepiece of any coherent policy package. Unlike more targeted regulations and subsidies, carbon pricing does not require information as to where and when lowest-cost emissions reductions might occur. Instead, it relies on market forces and lets emitters identify their own low-cost opportunities to reduce GHG emissions.

In some cases, there may be scope to *broaden* the existing coverage of carbon pricing systems. British Columbia's carbon tax, for example, covers only combustion emissions, excluding industrial process emissions, such as those produced by cement manufacturing facilities. These emissions are covered, however, for large emitters in Alberta, Ontario, and Quebec. Extending carbon pricing to cover these emissions will deliver more cost-effective mitigation than will targeting them with complementary climate policies.

In short, governments should trust their carbon prices to achieve large-scale emissions reductions at the lowest possible cost.

Fill the biggest gaps in coverage

As we have noted, some GHG emissions are difficult to price. In particular, emissions from small, distributed, non-point sources can be challenging to measure, even though actions to *reduce* these emissions might have quantifiable outcomes. Complementary policies can play an important role in these cases.

Extending the overall coverage of a package of policies to more GHG emissions can reduce costs. Broader coverage means fewer low-cost abatement opportunities are left unrealized. The priority for gap-filling policies, then, should be the largest sources of emissions outside of carbon pricing. Our case study on methane emissions from oil and gas production, for example, highlights an opportunity for substantial emissions reductions at relatively low cost.

The nature of gaps will vary from province to province, based on the specifics of provincial economic structures and energy profiles. In Alberta and Saskatchewan, for example, upstream oil and gas methane (from leaks and venting) make up about 11% and 16% of provincial GHG emissions, respectively. British Columbia's methane emissions are about 3% of that province's total, and are poised to rise with growth in natural gas and liquefied natural gas (LNG) production. In Manitoba, agricultural emissions contribute around one-third of the provincial total (Government of Canada, 2016d).

Boost signals where they are weakest

Complementary policies can also strengthen the impact of a carbon price by overcoming existing market failures. But how can policymakers identify the market failures (and corresponding policy solutions) that matter most? We propose the following three-step approach to identifying high priorities for signal-boosting complementary policies.

First, identify major sources of emissions that are relatively unresponsive to carbon pricing. Both modelling analysis and the existing literature can inform this assessment. Transportation, for example, is sometimes identified as a sector that is slow to decarbonize in response to carbon price signals, at least in the short term (Hughes et al., 2008; Kaufman et al., 2016). The building sector can also tend to respond slowly to the signal from carbon pricing, owing to their long lifespans and the risk of split incentive market failures (i.e., where building owners do not necessarily benefit from investments that improve energy efficiency) (Amano et al., 2010).

Second, identify the reasons *why* emissions within a given sector are slow to respond to the carbon price. A smaller or slower response to price signals does not necessarily justify the creation of additional policies. Some emissions reductions are more expensive than others, and will only occur in response to a high carbon price. The whole point of carbon pricing is to create incentives for the lower-cost opportunities for abatement to be realized rather than the expensive ones. However, if sectors are not responsive to a carbon price owing to important market failures, additional policy might be required. If so, governments should clearly identify the problem and why it requires policy intervention. For example, in the federal government's recent announcement of its intent to invest in electric vehicle charging infrastructure, it states the policy is intended to "address consumer concerns regarding the low availability of charging/refuelling infrastructure" (NRCan, 2016a).[47] In the absence of a clear rationale for policy, policies risk being driven purely by political or lobbying interests.

Third, identify policies that can cost-effectively solve the relevant market failures. Not all market failures have straightforward or cost-effective policy solutions. Consider the example of Quebec's PEV subsidies. Despite the strong case that market failures exist in the sector, our research shows that these subsidies are a very expensive policy solution. Alternative policies—for example, Quebec's zero-emission vehicle regulation—might address the same market failures, and drive the same emissions reductions, at much lower cost.

Focus on overlap between large emissions reductions and large co-benefits

Governments have multiple policy priorities. Relying on a single instrument to achieve multiple objectives often means that *none* of the objectives are achieved at lowest cost (see, for example, our work on biofuel policies [Canada's Ecofiscal Commission, 2016b]). As a result, policymakers should be wary of policies with ambitions of "killing two birds with one stone."

Still, as we discussed in Section 3, some GHG policies do generate co-benefits that might justify their use as a complementary policy—what we have called benefit-expanding policies. For example, as our case study of the phase-out of coal-fired electricity suggests, reducing air pollutants in conjunction with GHG emissions can lead to significant health benefits. Research from the International Monetary Fund (Parry et al., 2014) comes to the same conclusion: A carbon price of about $30 per tonne makes economic sense for Canada, *independent of the global benefits from reduced GHG emissions*, given local benefits from reducing air pollutants and improving human health.

How can this trade-off between pursuing genuine co-benefits and seeking cost-effective policy packages be managed? We suggest that high-cost GHG policies that nonetheless deliver co-benefits should not be a priority. In many cases, policies can drive lower-cost

[47] The implied market failure is due to network externalities: uptake of EVs would increase if there were well-developed charging infrastructure, but so long as the market remains small, the private sector will be slow to build it. A strong case can therefore be made for public investment in this infrastructure.

GHG reductions when aimed specifically at one objective. Similarly, other objectives can be achieved at lower cost through separate, distinct policies designed specifically for the problem at hand.

However, benefit-expanding policies can be practical in some cases. In particular, they are more likely to make sense if the nature of the co-benefits is closely tied to GHG emissions reduction. In the case of coal-fired electricity, for example, burning coal is directly related to both GHG emissions and air pollutants such as particulate matter. In these cases, the costs of trying to achieve two objectives at the same time may be small. Further, the concrete benefits associated with other objectives might be an opportunity to create political buy-in and broaden support for ambitious (and cost-effective) GHG policies.

The case of biofuel subsidies offers a contrary example. Reducing GHG emissions and secondary objectives such as "rural economic development" are less obviously aligned (Canada's Ecofiscal Commission, 2016b). There are multiple ways to provide support to rural communities that are unrelated to the production of biofuels. Similarly, there are more cost-effective ways to reduce GHG emissions. Both objectives could be more cost-effectively achieved through separate policies.

6.2 DESIGNING A COHERENT POLICY PACKAGE

In a cost-effective policy package, separate policy elements work together, rather than at cross-purposes. We explore the design of a coherent policy package below, building on analysis from Section 3 regarding both individual policy costs and interactions between policies.

Harmonize implicit and explicit carbon prices

A policy package will be more cost-effective when implicit and explicit carbon prices are harmonized. The logic here is the same as that underpinning the case for carbon pricing. If the cost per tonne of GHGs reduced is high for one policy measure, relying more on other policy measures for the same mitigation could reduce the overall costs of the package. Carbon pricing automatically establishes a consistent incentive to reduce emissions.

Policymakers can calibrate complementary policies to their explicit carbon prices through careful design. In particular, they can apply economic modelling analysis to estimate the implicit carbon price of the complementary policy and then adjust the policy until its implicit price aligns with the explicit carbon price (e.g., OECD, 2013b). The key design choice here is stringency: more-stringent policies will typically have a higher implicit carbon price (and drive more emissions reductions).

Complementary policies can also rely on market-based mechanisms to more explicitly calibrate stringency. Many regulations, for example, rely on tradable permits to reduce overall costs (e.g., federal vehicle regulations). But such policies could also be designed such that governments would make *additional* permits available at a given price. The price of these additional permits could be harmonized with the price of carbon under a carbon tax or a cap-and-trade system. Jaccard et al. (2016), for example, propose a similar regulation for industrial emitters.[48]

In most cases, however, the true costs and benefits of a complementary policy—and thus the implicit carbon price—cannot be precisely estimated until after the policy is implemented and data collected. Therefore, governments should establish processes to carry out regular reviews and make alterations in light of the results. We return to this point below.

Use caution with overlapping policies

As we saw in Section 3, policy interactions complicate the design of a coherent policy package. Interactions between policies can reduce effectiveness, and can also increase overall costs. These issues can be particularly challenging in terms of interactions between federal and provincial policies.

Adverse interactions can occur when different policies apply to the same GHG emissions. Complementary policies might target emissions also covered by the carbon price. Provincial and federal policies might apply to the same sector. Unless these overlapping policies have other objectives—either addressing market failures or driving other co-benefits—they will increase overall costs, and may not drive additional emissions reductions.

These issues become particularly complex in the context of multiple policies from multiple levels of government, where there is significant variation across provinces. Consider the case of the federal clean fuel standard (CFS) recently proposed as part of the Pan-Canadian Framework (Government of Canada, 2016a). The CFS could interact with existing provincial regulations on the emissions intensity of fuels. The CFS is designed as a flexible regulation. This flexibility means that actions will be taken wherever they are most cost-effective, and the overall cost of the policy will be minimized. But in combination with provincial policies, the same flexibility

[48] This kind of policy is analogous to Alberta's Specified Gas Emitters Regulation, which established a performance standard but allowed for flexibility in compliance through permit trading or contributions to a technology fund. Alternatively, offset markets can complement a carbon pricing system; trading would automatically align marginal carbon prices.

can undermine the policy's performance.[49] Regulated firms with operations in multiple provinces could comply with federal policy by focusing reductions in provinces with more aggressive policy. The upshot is that federal policy leads to only some *incremental* emissions reductions, relative to those from provincial policies alone. Yet this abatement is also potentially more expensive if low-cost emissions reductions are left unrealized in provinces with weaker policy. In other words, interactions might effectively reduce the flexibility of a federal policy, undermining its performance.

The bottom line is that these interactions have complex implications for costs, for emissions reductions, and for fairness across provinces. They highlight a need to coordinate both carbon pricing and non-pricing policies across the country; we return to this point below.

Use integrated modelling to forecast total emissions reductions and assess interactions

Simply adding up expected emissions reductions from each individual policy is insufficient. In particular, the issue of policy interactions complicates the analysis. As discussed in Section 3, non-pricing climate policies might apply to the same emissions as a carbon price. Similarly, multiple non-pricing policies might apply to the same emissions reductions. For example, a low-carbon fuel standard will also drive emissions reductions that might have been driven by the carbon price alone, or by a renewable fuel mandate alone. In other words, the emissions reductions from a policy in *isolation* are likely different from those resulting from the policy in *combination* with other policies.[50] Since a package of policies is precisely the approach Canada is taking, these are important issues.

Integrated economic modelling (such as the model employed by Environment and Climate Change Canada, E3MC) can account for interactions between different policies and reveal where they might require attention (NRTEE, 2008, 2009). Further, it can also take account of different carbon pricing instruments' differing implications for emissions reductions. The same complementary policy might lead to additional GHG mitigation in a carbon-taxing jurisdiction, while its additionality in a cap-and-trade jurisdiction might depend on whether the cap is binding and whether the system has a floor price.

6.3 COORDINATING AND IMPROVING POLICIES OVER TIME

By carefully choosing and designing complementary policies, governments can maximize the coherence of their climate policy package. Yet these efforts are likely insufficient to implement an overall package that is both effective and cost-effective. To complete the process, coordination between different governments in Canada may be required, and adjustments to the policies made over time.

Define processes for intergovernment coordination

As noted above, there is a risk that interactions between federal and provincial climate policies will undermine the cost-effectiveness of the policy package as a whole. Efforts to coordinate policies can help limit this risk.

Recent experience illustrates opportunities for collaboration and coordination between governments. At the First Ministers' Meeting in December 2016, all but two provinces signed on to the Pan-Canadian Framework (Government of Canada, 2016a). The framework is a starting point for coordination, not just of carbon pricing policies, but also a range of other complementary policies.

Different kinds of intergovernmental processes can balance flexibility and consistency across provinces. Snoddon and VanNijnatten (2016) consider processes used to coordinate various policies—including income taxes, sales taxes, and various environmental standards—between federal and provincial governments across Canada. Various processes and forums—including bilateral agreements, the Council of the Federation, and the Canadian Council of Ministers of the Environment—have played a role in intergovernmental policy coordination in Canada.

Key questions to guide policy development include: Is coordination more critical for some complementary policies? Which level of government is best suited to implementing some kinds of climate policies? What role should municipal and local policies play?

Implement a regular review and evaluation of GHG policies

There are good reasons to periodically review the performance of all policies, but reviewing policy packages is particularly important, for all the reasons discussed above. Creating a coherent policy package is challenging in theory, and even more so in practice.

[49] Whistance et al. (2017) highlight similar interactions between the state-level fuel policies in California and national fuel standards in the United States.

[50] More subtle interactions might also matter. For example, if a given policy changes the price of goods, services, labour, or capital, these changes might also have implications for the effectiveness of other policies.

Have complementary policies reduced emissions, and at what cost? Are they successfully overcoming market failures? Are they interacting with carbon pricing—and with each other—in ways that support the effectiveness and cost-effectiveness of the policy package?

A strong review process is essential to ensuring that climate policy packages remain effective and cost-effective. If policy proves to drive insufficient emissions reductions for achieving objectives, stringency can be increased to close the gap (OECD, 2015). Similarly, most mitigation policies have an "intermediate goal," such as reducing carbon intensity, improving energy efficiency, or reducing consumption (Kameyama & Kawamoto, 2016). Evaluating policy instruments or packages according to these intermediate goals can provide better information on how a policy is performing as part of a package. Adaptive governance can be a useful tool for evaluating climate policies, because it allows policymakers to learn over time, particularly at the regional level, where governments may be able to make adjustments in response to new information more quickly (Arvai et al., 2006; Brunner & Lynch, 2010).

This process of evaluation and adjustment is particularly important for signal-boosting policies. As we noted, the extent to which a true market failure exists—and the extent to which a given policy cost-effectively overcomes this market failure—is often complex and uncertain. Rigorous evaluation and clear protocols for policy improvement can help manage this uncertainty and reduce the risk of entrenching high-cost policies.

Consider asymmetric policy impacts across provinces

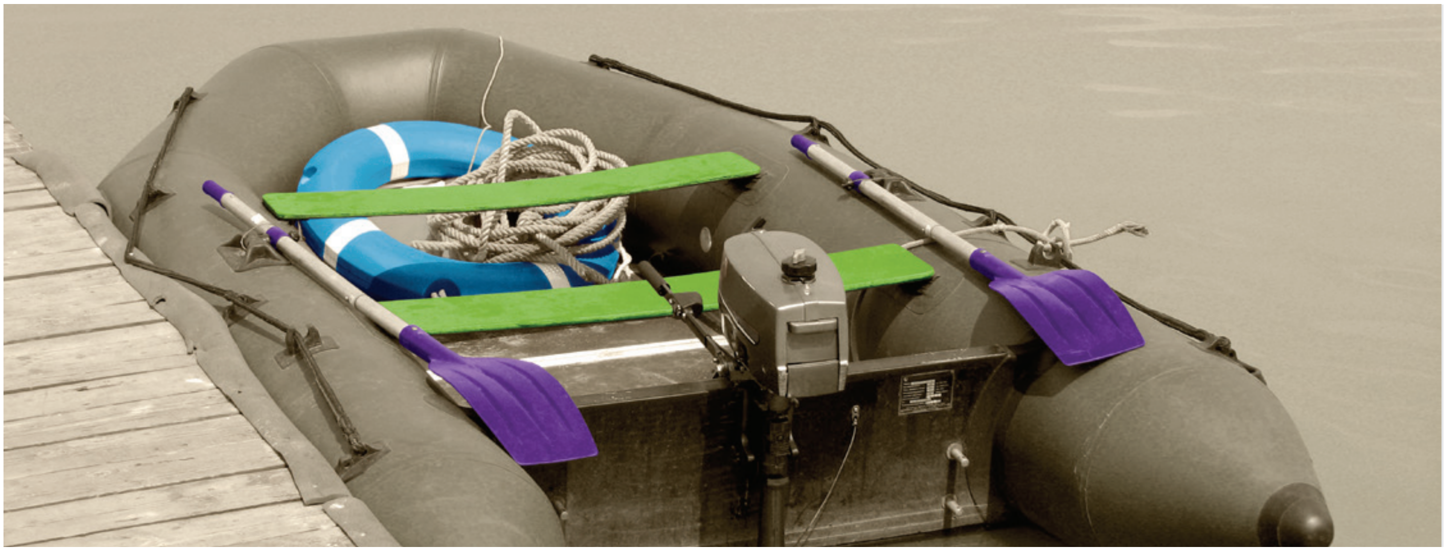
Key differences between carbon taxes and cap-and-trade systems, in combination with the structure of the Pan-Canadian Framework, can cause complementary policies to create uneven impacts across provinces. These differing impacts have important implications for both the distribution of emissions reductions across provinces and the overall cost of mitigation from packages of climate policies, both provincial and federal. As a result, interaction effects may interfere with the efforts of the framework to coordinate policy, and thus may increase overall mitigation costs.

First, consider *federal* policies that overlap with carbon pricing policies, such as the proposed clean fuel standard. In British Columbia and Alberta, this policy will lead to emissions reductions beyond those from existing provincial carbon taxes. It will also drive additional costs. Yet in Ontario and Quebec, the policy may not affect overall GHG emissions—instead affecting costs and permit flows—given interactions with the cap-and-trade system. The result is higher costs in carbon taxing provinces, and costs that may either rise *or* fall in cap-and-trade provinces.[51] These different impacts could raise challenging questions about how the burden of GHG mitigation is distributed and could significantly complicate federal-provincial policy implementation.

Second, consider the incentives the Pan-Canadian Framework creates for *provincial* adoption of complementary policies. The framework requires provinces to price carbon either through a minimum carbon tax or a cap-and-trade system with a declining cap consistent with the national GHG target. Yet this instrument flexibility affects the incentives for implementing complementary policies. In cap-and-trade provinces, any overlapping non-pricing policies contribute toward the emissions reductions required under the framework. Additional emissions reductions from complementary policies means that less mitigation is required from carbon pricing to achieve the cap (and as a result, there will be a lower carbon price and/or fewer international permit imports). In carbon-tax provinces, however, any new mitigation from complementary policies is *additional* to what occurs under their carbon price, and does not contribute toward meeting the requirements of the framework. To the extent that the GHG mitigation ambition of a carbon-taxing province is only defined by the requirements of the Pan-Canadian Framework, it may choose to leave opportunities for low-cost mitigation from complementary policies unrealized. The upshot would be higher overall cost of GHG mitigation and additional complications for firms operating in multiple provinces with divergent policies.

These effects could increase the differences in explicit carbon prices seen across provinces. Federal complementary policies would decrease the demand for permits in cap-and-trade jurisdictions (and thereby the price of carbon), but have no effect on the price of carbon seen in taxing jurisdictions. Similarly, greater uptake of provincial complementary policies expected from cap-and-trade jurisdictions (compared with taxing jurisdictions) would have the same effect. These differing impacts of national-level complementary policies and the differing uptake of provincial-level ones could act to increase the difference in carbon prices already seen across cap-and-trade and carbon-tax jurisdictions in Canada. This increased misalignment of explicit provincial prices on carbon would increase the overall cost of GHG mitigation in Canada.

[51] This is because a non-pricing policy that overlaps with a cap-and-trade system will *displace* mitigation that would have occurred elsewhere under the cap. Its net impact on costs will depend on the extent to which it cost-effectively addresses market failures or delivers co-benefits, and how it is designed.



7 RECOMMENDATIONS

Two objectives run throughout this report. Climate policies should be effective at reducing GHG emissions. And they should be cost-effective, in that they achieve these reductions at the lowest possible cost. Policies implemented in addition to carbon pricing can achieve these objectives and play an important role in an overall policy package, but only if they are designed carefully.

To support the development of a package of policies that genuinely complements carbon pricing, we make the following recommendations:

RECOMMENDATION #1:
Governments should make carbon pricing the core of their climate policy, with steadily increasing stringency

There is a role for non-pricing policies as part of an effective and cost-effective policy package for reducing GHG emissions. Yet to achieve reductions at lowest cost, these policies should *complement* rather than substitute for carbon pricing. The price of carbon should continue to rise—steadily, consistently, and predictably—beyond 2022 and well past $50 per tonne.

RECOMMENDATION #2:
Governments should clearly demonstrate complementarity before adopting non-pricing policies

More GHG policies do not necessarily make for a better climate strategy. Additional, non-pricing policies can increase costs and undermine the effectiveness of a carbon price. Policymakers should focus their efforts on policies that clearly have one of the three rationales explored in this report. They should fill gaps in carbon pricing policies, boost the signal of the carbon price, or generate significant co-benefits. Policies that do *not* fall into at least one of these categories will not be complementary to a carbon price. Governments should therefore *clearly demonstrate* the complementarity of proposed non-pricing policies prior to their adoption. This requirement can help limit high-cost policies. It can also limit undue influence from interest groups and industries seeking preferential treatment under prescriptive or technology-specific climate policies.

RECOMMENDATION #3:
Governments should strive to coordinate carbon pricing and complementary policies across the country

Over time, if differences between carbon prices across provinces and territories increase, pan-Canadian climate policy will have higher costs than necessary. Similarly, differences in complementary policies—and differences in interactions between carbon pricing and other policies—can increase overall costs. In both cases, the issue of inter-jurisdictional coordination and burden sharing is complex. All levels of government will continue to share jurisdiction over climate policy. Therefore, it is all the more important that they continue to cooperate to ensure that policies work together coherently.

RECOMMENDATION #4:
Governments should regularly review and assess both individual climate policies and the larger policy package

The many design features of complementary policies have significant implications for emissions reductions and the costs of achieving them. Interactions between policies add to the complexity of designing an overall package. And as this paper illustrates, identifying effective and low-cost complementary policies requires judgment and leaves room for debate. Identifying cost-effective signal-boosting policies can be particularly challenging, given uncertainty around the nature of potential market failures. As a result, no matter how carefully governments design a policy package, they should plan for regular review and assessment of its actual performance. Policy review and evaluation creates an opportunity for ongoing adjustment and improvement, and is always well advised—but especially so for complementary climate policies. Such "ex-post" analysis can provide critical insight into the coherence of the climate policy package, and how efficiently the burden of emissions reductions is being distributed across provinces and territories. Strong processes for review and adjustment to policies can create space for taking measured risks in implementing policy: high-cost or ineffective policies are less problematic in the long term if mechanisms exist to phase out those that perform less well in practice than theory. Governments can carry out this evaluation themselves, or they can choose to commission independent, objective evaluations of policy performance.

RECOMMENDATION #5:
Governments should rely on integrated modelling to assess the overall effectiveness of proposed and existing policies

This report highlights interactions between policies as a particularly thorny issue, especially in terms of their potential asymmetric impacts across provinces. These interactions clearly merit special attention. Indeed, the combined impact of federal and provincial climate policies should be regularly assessed. The means by which the interactions are assessed, however, is important. Only economy-wide, integrated modelling can provide a full examination of these effects.

To a limited extent, the federal government currently performs this function, through its annual Canada's Emissions Trends publication, which projects future Canadian emissions using Environment and Climate Change Canada's (ECCC) integrated modelling system, E3MC. Though not explored by this publication, ECCC's modelling system is well suited to take into account the interactions between policies. Future public analysis from ECCC could explore policy interactions in more detail. By comparing modelling analyses with and without overlapping policies, it could examine the significance of policy interactions between different policies at different levels of government, which would help in identifying opportunities for harmonization and coordination.

However, it may be more appropriate that this function be performed by an independent agency or commission, or new institutions providing oversight of the Pan- Canadian Framework. Notwithstanding the important governance issues to be resolved, making this type of analysis and assessment publicly available would improve transparency and accountability as Canada moves toward achieving its longer-term emissions-reduction targets.

RECOMMENDATION #6:
With the implementation of an economy-wide carbon price, governments should phase out and avoid redundant, high-cost, or ineffective policies

All Canadian governments should seek to identify and eliminate existing policies that no longer make sense given the implementation of economy-wide carbon pricing. In past years, these existing policies may have represented practical policy approaches in the absence of carbon pricing; today, they are unlikely to be either as effective or cost-effective as a broad-based carbon price. The emergence of pan-Canadian carbon pricing as a policy norm creates an important opportunity to shift toward more cost-effective policy by clearing the books of some older and higher-cost regulations and subsidies. Governments should only employ additional policies that are genuinely complementary to carbon pricing.

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Appendix A: Sample of Existing and Proposed Canadian Federal and Provincial Non-Pricing Climate Policies

Policy	Jurisdiction	Description
Agriculture		
Voluntary information programs	Federal	Farming methods to enhance carbon sequestration
Emissions standards	Alberta	Manure management regulations
Energy efficiency programs for farmers	Alberta	Funding to help farmers reduce emissions and improve energy efficiency
Agricultural Soil Health and Conservation Strategy	Ontario	Develop soils management practices that reduce GHG pollution; improve long-term capacity for soil carbon sequestration
Strategies to enhance natural sequestration	Ontario	Maximize long-term carbon storage in agricultural soils; increase tree planting; expand the Greenbelt; develop a stewardship initiative for provincial grasslands; improve monitoring of natural carbon storage systems
Buildings		
Increasing use of wood for construction	Federal	Updating building codes to encourage using wood in the construction of new buildings
National Energy Code of Canada for Buildings	Federal	Technical requirements for the energy-efficient design and construction of new buildings
Net-zero building codes	Federal	Adoption of more-stringent model building codes starting in 2020, with the goal of adopting net-zero-ready code by 2030
Energy efficiency informational programs	Common across provinces	Informational programs for households looking to improve energy efficiency
Energy efficiency rebate programs	Common across provinces	Rebates for households that invest in energy efficiency improvements
Energy efficiency subsidies	Common across provinces	Subsidies for households, businesses, and institutions to improve energy efficiency of buildings
Residential energy efficiency programs	Common across provinces	Assistance for low-income households to make energy-efficient retrofits to their homes
Government building standards	British Columbia	Promotion of use of low-carbon materials in new government buildings; emissions reduction plan for existing buildings
Net-zero building regulations	British Columbia	By 2030, all newly constructed buildings must be net-zero emissions
Electric vehicle network regulations	British Columbia, Ontario	Investments in public charging stations; requirements for charging stations in new homes
Energy Efficiency Alberta	Alberta	Agency delivering programs to help households, businesses, and communities become more energy efficient
Solar rebate program	Alberta	Rebates for solar installations on residential and commercial buildings
Efficiency testing	Ontario	Mandatory energy efficiency testing and auditing for buildings
Energy efficiency targets	Ontario	Long-term energy efficiency targets for small net-zero buildings
Energy efficiency targets	Ontario	Standards and financial incentives to improve efficiency of residential and public buildings
Net-zero home rebates	Ontario	Rebate program for individuals who build or purchase net-zero homes
Public facility retrofits	Ontario	Energy-efficient and low-carbon retrofits; strengthening performance standards for existing buildings
Cities		
Densification policy	British Columbia	Identifying tools to focus growth near transit corridors

Policy	Jurisdiction	Description
Electricity		
Linking electricity infrastructure between jurisdictions	Federal	Addressing the intermittency of renewable power by improving grid connectivity
Modernizing electricity systems	Federal	Support for the demonstration and deployment of smart-grid technologies
Reducing reliance on diesel	Federal	Programming to accelerate efforts to improve diesel efficiency, and install hybrid and renewable electricity systems in indigenous and northern communities
Renewable electricity program	Alberta	Competitive bidding process to increase the proportion of renewable power in province's electricity mix
Renewable energy credits	Alberta	Per-unit generation subsidy for renewable energy projects
Renewable portfolio standard	Saskatchewan	50% renewable generation target by 2030
Feed-in Tariff program	Ontario	Guaranteed rate of return ($/kWh) for new renewable electricity projects
Renewable portfolio standard	New Brunswick	40% renewable generation target by 2020
Funding for Fundy Ocean Research Center for Energy	Nova Scotia	Investments in tidal energy to displace coal-fired electricity
Renewable portfolio standard	Nova Scotia	40% renewable generation target by 2020, plus cap on electricity sector emissions
Energy		
Energy Innovation Program	Federal	Support for R&D in clean-tech sector
Incandescent bulb phase-out	Federal	Mandatory phase-out; efficient light bulb standards introduced
Program of Energy Research and Development	Federal	Interdepartmental initiative providing support for "a sustainable energy future"
Voluntary information programs	Federal	Energy efficiency campaigns (e.g., EnergyStar)
Alternative Energy Technologies Program	Northwest Territories	Assistance for residents to integrate clean-energy technologies on their properties to reduce fuel consumption
Forestry		
Enhancing sequestration in forests	British Columbia	Programs to rehabilitate under-productive forests, improve wood fibre recovery, and avoid emissions from burning slash
Industry		
Amendments to Montreal Protocol	Federal	Amendment requiring signatory countries to phase-out HFCs
Cleantech Fund	Federal	Support for green innovation projects
Efficiency standards	Federal	New federal standards for efficiency in heating equipment
Business energy rebates programs	Common across provinces	In-store and mail-in rebates for energy-efficient equipment in a business, non-profit, or institutional setting
Business energy-saving incentives	Common across provinces	Assistance for businesses looking to reduce energy operating costs
Industrial Systems Program	Common across provinces	Range of measures and financial incentives to make industrial facilities, processes, and electromechanical systems more energy efficient
Industrial demand-side management programs	British Columbia	Efficiency standards for gas-fired boilers; incentives to adopt efficient gas equipment; electrification programs
Alberta Emissions Offset Registry	Alberta	Offset credit market for demonstrable emissions reductions not covered by carbon price
Phasing out coal-fired electricity	Alberta, Ontario, Federal	Required phase-out of all coal-fired electricity generation

Policy	Jurisdiction	Description
Land use		
Increasing stored carbon	Federal	Improved tracking of natural sequestration potential
Development of land-use carbon inventory	Ontario	Enhancing natural carbon sinks
Oil and gas		
Ending fossil fuel subsidies	Federal	G20 agreement to phase out subsidies to oil and gas by 2025
Methane regulations	Federal	Various engineering and process regulations to reduce sectoral methane emissions
Carbon capture and storage (CCS) regulations	British Columbia	Providing regulatory clarity on CCS issues such as site selection, monitoring, and long-term liability
Oil sands emissions cap	Alberta	Hard 100 Mt cap on emissions from oil sands
Other		
Sustainable Development Technology Canada's tech fund	Federal	Development and pre-commercial demonstration of clean tech
Green bank	Ontario	Financing and support services for emissions-reducing projects for households and businesses
R&D support	Ontario	Tax and regulatory policies to encourage innovation in clean tech
Transportation		
Clean Fuels Standard	Federal	Required reductions in the life-cycle emissions intensity of Canadian fuels
Financial support for public transit	Federal	Improve availability of low-emissions public transportation options
Vehicle emissions standards	Federal	Increasing the stringency of standards for emissions from light-duty and heavy-duty vehicles
Converting commercial fleets to natural gas	British Columbia	Financial incentives for organizations to convert vehicle fleets to natural gas
Low-carbon fuel standard	British Columbia	Requirements for low emissions-intensive carbon content in transport fuels
Electric vehicle subsidies	British Columbia, Ontario, Quebec	Partial rebate for purchasers of electric vehicles; other forms of financial support
Flexible fuel mandate	Ontario	Required 7.5% ethanol blending rate
Improving cycling networks	Ontario	Expand cycling networks in key corridors to improve their viability as an alternative to driving
Increasing the use of low-carbon buses and trucks	Ontario	A suite of incentives and programs to reduce emissions from heavy-duty vehicles
Zero-emission vehicle standards	Quebec	Electric vehicle production quota, facilitated by permit trading
Waste		
Waste methane capture regulations	Common across provinces	Requires assessment and/or collection of landfill gas above a threshold of disposal volume, but does not dictate end use
Landfill diversion targets	Ontario	Target of 40% of organics diverted by 2025, and 60% by 2035
Pilot projects for waste energy	Ontario	Piloting a program that uses methane from agricultural materials or food wastes for transportation; funding for commercial-scale demonstration projects
Solid Waste Resource Management Regulations	Nova Scotia	Compostable organic materials prohibited from landfills

Appendix B: The Social Cost of Carbon

The social cost of carbon (SCC) quantifies the cost of an additional tonne of carbon dioxide in the atmosphere in a given year. It is the incremental global damage that climate change will cause as a result of that additional tonne. Environment and Climate Change Canada uses two SCC values based on research and analysis conducted by the U.S. Interagency Working Group. The first value reflects the central tendency for SCC. The second value is the 95th percentile value for SCC, which reflects low-probability, high-cost outcomes and is recommended for sensitivity analysis. The SCC values were last updated in 2013.

The values in Table B1 are derived from three peer-reviewed, global, integrated assessment models (IAMs). An IAM is a computer-based integrated model that allows for high-level aggregation of a large number of data sets. The three IAMs calculate the expected damages of a tonne of CO_2 over time using a variety of parameters. They incorporate climate data, emissions forecasting, and the impacts of climate change on agriculture, human health, property damage, and ecosystem services. They are run 10,000 times, drawing randomly from the equilibrium climate sensitivity (ECS) probability distributions, and five sets of forecasts for GDP, population, and emissions trajectories through the year 2300. The ECS describes how the global annual mean surface air temperature responds to a doubling of atmospheric CO_2 concentrations relative to pre-industrial levels, once it reaches equilibrium.

There are a wide range of estimates for the SCC, due in large part to the discount rate applied to emissions (5%, 3%, and 2.5% are used in the IAMs) and the presence of low-probability, catastrophic outcomes and events associated with anthropogenic greenhouse gas emissions. Canada uses a 3% social discount rate for carbon, consistent with the country's Treasury Board Secretariat's *Canadian Cost-Benefit Analysis Guide* (Treasury Board of Canada Secretariat, 2007). A lower discount rate places greater value on future costs and raises SCC values over time. Beyond the inherent limitations of the models, the evolving state of scientific knowledge adds additional uncertainty to the SCC values.

A recent report by the National Academies of Sciences, Engineering, and Medicine (2017) suggests a number of changes to the IAM methodology, including greater transparency, improved characterization of uncertainties, and an update to ensure that the best available science informs the basis for the models. The most notable recommendation is an "unbundling" of four separate modules within the IAMs to account for population estimates, world economic outputs, temperature changes, damages, and discount rates sequentially and separately from one another. The report also recommends that fixed discount rates be discontinued and replaced with rates that consider the relationship between growth and discounting. These changes to the models increase the 3% discount SCC to approximately $57/tonne.

Table B1: Canadian SCC estimates ($2012 per tonne CO_2, 3% discount rate)[52]

Year	Updated Central	Updated 95th Percentile
2010	$34.10	$131.50
2013	$37.40	$149.30
2015	$39.60	$161.10
2016	$40.70	$167.00
2020	$45.10	$190.70
2025	$49.80	$213.30
2030	$54.50	$235.80
2035	$59.60	$258.90
2040	$64.70	$281.90
2045	$69.70	$300.90
2050	$74.80	$319.80

An alternative method for determining SCC can be found in Pindyck (2016). This approach is critical of IAMs and argues that some of the inputs, in particular the damage functions that correlate GDP losses to a specific temperature increase, are ad hoc and create a false perception of precision. Pindyck argues that the true objective of SCC is to determine the likelihood of catastrophic outcomes, and, given their limitations, asserts that IAMs are incapable of accurately assessing these probabilities.

Pindyck's approach focuses on the likelihood of extreme economic outcomes and the reduction in emissions required to avoid these outcomes. It is indifferent to the causes of these extreme outcomes (i.e., large drops in GDP without large temperature increases, or large increases in temperature with small decreases in GDP, or some mix of these extremes). These probabilities are informed by broad-based expert opinion and take into consideration the level of confidence expressed in the answers given. Pindyck argues that given the 3% discount rate applied for

[52] In the body of the report, figures cited for the SCC are expressed in 2017 dollars.

future consumption in IAMs, moderate climate impacts will not cause enough damage to matter. This is the basis for the emphasis on extreme outcomes.

This model benefits from greater transparency and simplicity when compared with IAMs. Pindyck argues that the focus on extreme outcomes simplifies the problem and targets the scenarios that we most want to avoid, but concedes the difficulty in determining the likelihood of this subset of scenarios. However, Pindyck maintains that since both approaches rely on expert opinion, this model's simplicity renders it superior to IAMs.

This approach finds that many experts believe the probability of extreme outcomes is quite high, but a "trimming" of the pool of respondents to exclude outliers below the 5th percentile or above the 95th percentile reduces the number significantly. As seen in Table B2, in most cases, Pindyck's method yields SCC values greater than the median distribution in Environment and Climate Change Canada's IAM models, but lower than its 95th percentile distributions.

Table B2: Pindyck SCC estimates (US$2016 per tonne CO_2)

Parameter	All respondents, <5th and >95th percentile trimmed	Respondents who expressed high confidence, <5th and >95th percentile trimmed	All respondents, <10th and >90th percentile trimmed	Respondents who expressed high confidence, <10th and >90th percentile trimmed
Gamma (thin-tailed dist'n)	$208.5/tonne	$107.6/tonne	$146.9/tonne	$66.5/tonne
Lognormal (intermediate, fat- and thin-tailed dist'n)	$278.1/tonne	$135.2/tonne	$217.2/tonne	$83.6/tonne
Pareto (fat-tailed dist'n)	$15/tonne	$4/tonne	$14.8/tonne	$2.6/tonne
Frechet (generalized extreme value)	$295/tonne	$137.9/tonne	$243.4/tonne	$86/tonne

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