Is Win-Win Possible?

Can Canada's Government Achieve Its Paris Commitment . . . and Get Re-Elected?

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Executive Summary

For almost three decades, economists have told politicians they must rely on emissions (carbon) pricing to achieve GHG targets. Politicians have mostly ignored them. The new Canadian federal government committed at the UN climate summit in Paris to reducing national emissions 30% in just 14 years and has promised a minimum national emissions price. But we find that to achieve the Paris commitment a Canada-wide emissions price would need to start at $30 per tonne of CO_2 and rise $15 annually to $200 in 2030. It is highly unlikely that our political leaders will implement such a price, given the severe political consequences.

In this report, we offer an alternative policy approach in which the federal government would apply flexible regulations in key sectors – transportation, electricity generation, industry, etc. – in conjunction with a modest emissions price, reaching $40 by 2030. These regulations approximate the incentives and flexibility of emissions pricing, but comparative surveys of climate policy acceptability, and experience in leading jurisdictions, indicate that they are likely to be less politically difficult. Researchers find, for example, that the energy transition in California is driven primarily by flexible regulations, not emissions pricing.

Politicians have typically traded-off policy effectiveness for political acceptability. In other words, they have opted for subsidies, information programs, moral incitation and public investments that were politically acceptable but ineffective in driving the transition to near-zero-emission vehicles, electricity generation, biofuel production, industrial processes and buildings. In the few cases where political leaders have implemented effective policies, they have preferred regulations with a high 'implicit' carbon price over high 'explicit' emission prices, such as a high carbon tax. This is unlikely to change.

If climate policy researchers and advisors are to provide useful advice to our political leaders, they should consider assessing the economic efficiency cost of flexible regulations relative to emissions pricing. The latter can undoubtedly be more economically efficient, but in the scenarios we report here this advantage may not be substantial, especially considering how emissions pricing is usually applied. And if a full reliance on emissions pricing is politically impossible, this extra cost may well be worth it.

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I. Rationale for this Report

I.1 Canada's Paris Climate Commitment and Its Policy Challenges

At the UN climate summit in Paris in late 2015, the Canadian government committed to reduce the country's greenhouse gas emissions to 30% below 2005 levels by 2030, with significant reductions continuing to mid-century. It subsequently made statements that this national commitment would be achieved in cooperation with the provinces and that a key policy tool would be 'emissions pricing,' also called 'carbon pricing' since CO_2 is the dominant greenhouse gas.

Based on past experience, simultaneously achieving these three objectives – (1) an ambitious national target, (2) agreement of its fair allocation among the provinces, and (3) emphasis on carbon pricing as the central policy – is an enormous challenge. First, past Canadian governments have set and then widely missed emission targets for 2000, 2005, and 2010, and the latest government analysis shows that the 2020 target will also be widely missed. Depending on the rate at which oil sands production is allowed to increase its emissions, the 2030 target is potentially even more ambitious than previous targets. Second, all efforts over the past two decades for federal-provincial agreement to achieve national targets have failed, most notably in the decade 1997-2007 after Canada signed the Kyoto Protocol. Third, no province has a carbon price higher than \$30 per tonne of carbon dioxide (\$30/tCO_2), and research from various sources suggests the need for a price six to seven times higher by 2030 in order to achieve the Paris commitment for emissions in that year. Given their reluctance to push for a rapidly rising carbon price, provincial premiers are undoubtedly aware that Stephane Dion's strategy of making carbon pricing a central policy in the 2008 federal election contributed to his electoral defeat.

Federal-provincial meetings in March and July of 2016 provided further support to the argument that these three objectives are simultaneously unattainable. Indeed, statements by many of Canada's political leaders already suggest a reframing. Instead of estimating the policy stringency that is needed for the country to achieve its 2030 commitment, many provincial leaders say they are already doing all they can. And, after vocal opposition to carbon pricing by some premiers, Prime Minister Trudeau suggested that the federal government may have to unilaterally impose a minimum carbon price throughout the country. This would not be a voluntary federal-provincial policy, nor would it be sufficient to achieve the national target if it is a minimum near the current level of carbon prices in British Columbia, Alberta, Ontario and Quebec. Furthermore, some premiers now refer to subsidies, like those supporting carbon capture and storage in Saskatchewan, and regulations, like those requiring more renewable electricity in Nova Scotia, as legitimate forms of carbon pricing.

Referring to subsidies and regulations as forms of carbon pricing would seem Orwellian to most economists. While economists recognize that subsidies can provide market incentives in the limited cases where they would be applied (one might call them 'negative carbon prices'), they would argue that the only true forms of carbon pricing are a broad-based carbon tax, as in British Columbia and Alberta, and the trading price of carbon allowances, as in the economy-wide cap-and-trade systems of Quebec and Ontario. Other climate policies fall into one of the following four categories: (1) information programs that try to incite voluntary action (energy-efficient fridge labels, advertisements); (2) subsidies to near-zero-emission technologies, fuels and R&D, which, as noted, can only affect a small percentage of total emissions; (3) government internal investment and management decisions that influence the carbon emissions of public infrastructure (such as transit) and publicly-owned buildings, equipment, and vehicles; and (4) regulations that range from 'command-and-control' (building codes, specific pollution control devices) to 'flexible' (performance standards, niche market requirements for low emission options without specifying technology or fuel outcomes).

Although these four types of policies are not carbon pricing, one could estimate the carbon price that would have been needed to achieve the same level of emission reduction as one or a package of these alternative policies. This is sometimes referred to as the 'implicit carbon price' of non-price policies, as opposed to the 'explicit carbon price' of a tax or tradable allowance price.[1] Thus, the government subsidy for carbon capture and storage at the Boundary Dam coal-fired power plant in Saskatchewan has been estimated to equate to an implicit carbon price of \$60-\$80/tCO_2 and the cost of closing still-viable coal plants in Ontario at an implicit carbon price of \$80-\$100/tCO_2.

The implicit carbon price may become an important concept if the federal government is unable to attain provincial agreement on the application of an explicit carbon price high enough to achieve its 2030 emissions commitment. Unless the federal government is willing to impose this nation-wide carbon price unilaterally, it will need to assess the relative costs and effectiveness of a diversity of climate policies, some quite different from one region to another. And, given the inability of governments anywhere in the world to impose high carbon prices during three decades of efforts to reduce emissions, the federal government may need to consider other policy options.

We prepared this study to help address this daunting challenge under the assumption that the federal government is sincerely determined to achieve its 2030 emissions commitment, and that it understands this requires the rapid implementation of effective policies. But, given that ineffectiveness has been the dominant trait of three decades of Canadian climate policy efforts, we believe that the design of any climate policy package should begin by reviewing lessons from social science research on why emission reduction efforts have so often failed. and why, in a few cases, some efforts have had modest success. In the next two sections, therefore, our discussion touches on research from behavioral economics, political science and social psychology. This discussion enables us to draw inferences about the value in considering climate policies that diverge from the 'must-price-carbon' narrative of several recent Canadian climate policy proposals. With these inferences as a guide, we then construct a portfolio of flexible regulatory policies that, if applied carefully, might approach the economic efficiency benefits of carbon pricing without facing as high a probability of public and interest group policy resistance, and therefore of political rejection.

We then apply a commonly-used energy-economy model to assess the potential contribution of this set of flexible regulations in achieving Canada's 2030 commitment and compare this to a policy approach in which such regulations are rejected in favor of a singular emphasis on carbon pricing. In presenting the results, we compare the two approaches in terms of costs and distributional effects.

I.2 Multi-Criteria Evaluation of Canada's Climate Policy Options

Economists frequently assess policies in terms of their cost-effectiveness – which policy incurs the lowest costs per unit of emissions reduced. This criterion is important, but it masks a critical distinction in the climate policy realm. For a climate policy can be cost-effective, yet ineffective. In 2007, Quebec

[1] Economists sometimes refer to implicit carbon prices as 'shadow' or 'imputed' carbon prices, or, somewhat facetiously, as 'unrevealed' carbon prices, as in "the public appears to prefer unrevealed over revealed carbon prices."

introduced a carbon tax of $3/tCO$_2$. A $3/tCO$_2$ tax increases the price of gasoline less than one cent per litre. In other words, it has less than a one percent price effect on a commodity whose retail price has fluctuated up and down by more than 50 percent during the past decade. Economists would rate the tax as cost-effective because it applies a carbon price. But none would argue that the tax has been effective in reducing emissions, nor would the Quebec government claim this.

This is why we separate economic efficiency from 'emissions effectiveness' in our four climate policy evaluative criteria: (1) economic efficiency, (2) emissions effectiveness, (3) political acceptability, and (4) administrative feasibility. By separating cost-effectiveness into distinct economic efficiency and emissions effectiveness components, we can assess trade-offs between these criteria. And, with this evaluative framework in mind, evidence of the past two decades supports the following observations about climate policies.

First, to be effective at significantly reducing emissions, a climate policy must apply either a rising carbon price or increasingly stringent regulations on technologies and forms of energy.[2] These two distinct approaches – carbon pricing and regulations – might together be referred to as 'compulsory' policies. It is essential to have at least one of these policies for policy effectiveness. In contrast, information programs and even subsidies will not cause significant emissions reductions throughout the economy. Information programs have been shown to have negligible effect. And a government would have to raise other taxes to stratospheric levels if it were to subsidize all major investments and operating expenditures in the economy in order to ensure the dominance of near-zero-emissions options over fossil fuel burning options. Information and subsidies can be part of the climate policy portfolio, but the heavy lifting for effective emissions reductions requires compulsory policies: carbon pricing and/or regulations.

Second, while it is frequently stated that carbon pricing itself is essential, this is not true. Canada could reach its 2030 target relying entirely on regulations. Or, it could rely entirely on carbon pricing. We must have at least one of these compulsory policies to achieve emissions effectiveness. But it does not have to be carbon pricing. Unfortunately, however, carbon pricing is sometimes mistakenly presented as a necessity. Some pro-market advocates argue for its necessity because they believe that it (especially a revenue neutral carbon tax) minimizes market intrusion by government. Some economists argue for its necessity because their professional training leads them to believe that all public policies should achieve societal objectives at minimal cost, which is the presumed strength of carbon pricing. The truth is that carbon pricing is a choice, not a necessity, for effective emissions reductions.

Third, carbon pricing is more economically efficient than regulations. It is conceivable that an unevenly applied and poorly administered carbon price could be less economically efficient than a carefully designed set of flexible regulations. But the likelihood is extremely small. Policy makers would have to work hard to achieve such incompetence.

Fourth, when comparing just the two emissions pricing options, a carbon tax should be more administratively simple than cap-and-trade. In practice, however, governments have usually introduced significant administrative complexity when implementing either form of carbon pricing. A notable exception is British Columbia's carbon tax, considered by most economists to be the purest in the world

[2] The following points are explained in greater detail, with supporting evidence and references, in Simpson, Jaccard and Rivers, Hot Air: Meeting Canada's Climate Change Challenge, McClelland and Stewart, 2007.

because of its uniform application to all fossil fuel-related carbon emissions in the economy, with all revenue returned as corporate and personal income tax cuts along with rebates to low income individuals. Ontario, in contrast, intends to use the revenues from auctioning emission allowances for a complex array of government climate programs which, if effective, will simply lower the allowance trading price without further reducing emissions.[3]

Fifth, all compulsory policies can be designed to partially protect trade-exposed, carbon-intensive industries from their competitors in jurisdictions with less stringent climate policies. This can be achieved in a number of ways depending on the compulsory policy. These vulnerable industries could face lower carbon tax rates or receive carbon tax rebates. In the case of cap-and-trade, they could receive free emission allowances or some portion of government revenues from allowance auctions. In the case of regulations, the regulatory stringency could be lower for these industries. Or the government could apply taxes to imports based on their carbon content and provide tax rebates to the vulnerable industries.

Sixth, all compulsory policies can be designed to reduce distributional impacts, be these among income groups or regions. Carbon pricing revenues, whether from carbon taxes or allowance auctions, can be returned disproportionately to income groups or regions in ways that partially offset the uneven incidence of the policy's cost. With regulations, there is no public revenue to distribute. However, regulations can be applied differentially to reduce costs for some groups or regions. And, as described in our policy package below, some types of flexible regulations induce retail pricing practices that cause compensating transfers between income groups, who are distinguished by their different purchasing habits (such as the purchasers of luxury cars versus those of budget models). Finally, if government is concerned about equity impacts, it has other means of addressing these through its regular activities of taxation and public expenditure. For example, while tightening building codes, some European governments have provided energy efficiency subsidies to low-income homeowners and social housing agencies. These are usually financed from general government revenues rather than carbon pricing.

I.3 Focusing on Political Acceptability

Economists often refer to redistribution policies as the mechanism by which governments ensure political acceptability for economically efficient policies. They note that well-crafted policies can address equity concerns without sacrificing economic efficiency. The simple trick is to design-in redistribution mechanisms that do not distort the pollution cost signal provided by carbon pricing. However, experiences in Canada and most other industrialized, democratic countries have shown that even with significant redistributive elements, perception can matter more than reality when it comes to public support for and interest group resistance to climate policy.[4] There are a number of reasons.

The goal of climate policy is to transition our economy away from devices that burn coal, oil and natural gas.[5] We already have all of the technologies and energy forms needed to achieve near-zero emissions

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[3] Of course perverse outcomes are possible. If government spent huge sums subsidizing reductions, it is possible that the cap would not be binding. (Emissions would fall below the cap.) In such a case, the allowance trading price would stay at its floor level. In this scenario, the demand for allowances could fall to very low levels, perhaps even to zero. If this occurred, the Ontario government would be stuck with spending commitments but no allowance revenues to pay for them.
[4] This may also be the case in other policy arenas, but our comments are limited to the climate policy research literature.
[5] Again, for simplicity, we ignore other greenhouse gases and focus on CO_2.

economy-wide.[6] But this transition will cause modest increases in the cost of energy services like electricity-specific uses, home heating and vehicle use. These cost increases would be exorbitant if we tried to make the transition in just a few years. But the cost is manageable if the transformation occurs at a pace that roughly matches the rate at which we normally develop new infrastructure and replace buildings, vehicles, appliances, and industrial plants and equipment. This results in three important characteristics.

First, the costs of the transition must begin now, while the major benefits will be realized as avoided climate change in the future. Since politicians typically serve in office for less than a decade, few of these benefits will be realized during their term, and given the global nature of the challenge, these benefits are uncertain anyway. This means that climate policy that is effective (that drives the energy transition) has a negative benefit-cost ratio in the political calculus: effective climate policy is far more likely to have a net-negative effect on a politician's electoral prospects.[7] Given that effective climate policy has this political cost, the only reason for a politician to implement such effective policy is a personal conviction about the importance of the climate change threat and a willingness to show leadership, even at a political cost. Not all politicians match this description.

Second, since the achievement of an effective energy transition takes several decades, it is difficult for the public, not to mention experts, to know if a set of policies are actually causing the necessary energy transition, when examined over the timeframe of a typical political career.[8] This creates a temptation for politicians to select distant targets for their climate commitments, since, if the target is missed, this will occur after their career is over. Former prime ministers Brian Mulroney, Jean Chretien and Stephen Harper did little to achieve their distant emission targets, but the failure only became apparent after they had left office, by which time public views about their performance mattered little. Moreover, this transition timeframe enables politicians to favor the most politically acceptable climate policies, even though independent experts, and their own advisors, tell them that these will be largely ineffective. Three decades of Canadian climate policies have been dominated by non-compulsory information and subsidy programs – sometimes referred to as 'faking it' policies. It appears that politicians were aware of this ineffectiveness when designing and implementing these policies.

Third, even when compulsory climate policies have been designed with mechanisms to minimize their impacts on particular individuals, groups, regions and industries, many people inherently presume that they will face significant impacts and dismiss contradictory evidence. Our research group has immediate experience with the reaction in 2008-2010 to British Columbia's new carbon tax, as we conducted independent and some government-funded analysis of claims that the policy harmed various groups – northerners, rural residents, suburban residents, the trucking industry, the cement industry, the

[6] For clear evidence, see Johansson et al., Global Energy Assessment: Toward a Sustainable Future, Cambridge University Press, 2012. For a recent Canadian source, see Expert Panel on Energy Use and Climate Change, Technology and Policy Options for a Low-Emission Energy System in Canada, Council of Canadian Academies, 2015.

[7] See Simpson, Jaccard and Rivers, Hot Air: Meeting Canada's Climate Change Challenge, McClelland and Stewart, 2007

[8] And to the extent that avoided costs are more extreme weather events, it is difficult for individuals to envision how each of them and their children might specifically benefit from climate policy. People cannot be sure that failure to act will cause a drought, flood, hurricane or infestation nor that they will be personally affected by such events. See, Hulme, Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity, Cambridge University Press, 2009 and Marshall, Don't Even Think About It: Why Our Brains Are Wired to Ignore Climate Change, Bloomsbury, 2014.

greenhouse industry.[9] Overall, our analysis and that of the government indicated that less than 20 percent of British Columbian's would be net financial losers under the carbon tax, as it rose in $5 increments from $10/t$CO_2$ in 2008 to $30 in 2012.[10] These would be almost entirely wealthy British Columbians with extremely wasteful use of gasoline, diesel and natural gas. Yet a survey found that over 70% of British Columbians were convinced that they were net financial losers under the revenue-neutral tax.[11] The more recent public and political debate over Alberta's carbon tax echoes the British Columbia experience.

These three factors help explain why, in many jurisdictions, not just Canada, the emission-reduction performance of politicians who seemed to sincerely want to reduce emissions has not been much better than that of politicians who were most likely faking it. They also explain the increasing interest of climate policy analysts in social science research on the real-world complexities and irrationalities of democratic policy-making processes in order to integrate this knowledge into efforts to design and implement climate policy.

In this report, we can only briefly summarize some of the lessons from this research. But these are important as they provide the rationale for the policy package that we highlight.

Decades of social science research has noted how interest groups that face concentred costs or concentrated benefits from a particular policy have a greater incentive to mobilize relative to the rest of the populace, for whom the benefits or costs are diffuse. And this imbalance in lobbying pressure can influence politicians to delay or reject policies whose net effect would have been positive for society as a whole.[12] Thus, industries, individuals and regions that especially benefit from fossil fuel production have an incentive to engage aggressively in the policy making realm to prevent or delay policies that would drive the needed energy transition. Research over the past decade has found that individuals and groups associated with the fossil fuel industry in particular have used a diversity of means, with considerable success, to rally opposition against effective climate policies.[13]

This line of social science research emphasizes people acting in their self-interest at the expense of society, but at least they are acting rationally to advance their own interest. However, another line of research emphasizes an even more troubling aspect of the democratic policy making process: namely, the widely-observed human propensity to reject sound evidence simply because it does not accord with one's pre-conceived beliefs about the nature of government and the trustworthiness of different groups. This research suggests that politicians have an incentive to cater to some extent to the delusions of individuals and groups when competing for votes.[14] Of particular relevance for assessing the

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[9] See Jaccard, "The Political Acceptability of Carbon Taxes: Lessons from British Columbia", in Milne and Andersen, Handbook of Research on Environmental Taxation, Edward Elgar, 2012.
[10] Some of the research was conducted under contract to the BC government by an associated consulting company (initially M.K. Jaccard and Associates, later Navius Resource Consultants) and some was conducted independently by our research group at Simon Fraser University. Contact co-author M. Jaccard for more information.
[11] See Harrison, "The Political Economy of British Columbia's Carbon Tax", OECD Environment Working Paper #63, OECD Publishing, 2013.
[12] See Olson, The Logic of Collective Action: Public Goods and the Theory of Groups, Harvard University Press, 1965.
[13] See Oreskes and Conway, Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming, Bloomsbury, 2010; and Hoggan, Climate Cover-Up: The Crusade to Deny Global Warming, Greystone, 2009.
[14] See Achen and Bartels, Democracy for Realists: Why Elections Do Not Produce Responsive Government, Princeton University Press, 2016; and Rosenfeld, Common Sense: A Political History, Harvard University Press, 2014.

implications for climate policy choices is the tendency for many people to believe that any government tax increase will harm them personally as well as the economy, and to reject contrary evidence, even when this evidence is the consensus view of independent experts.[15]

Anecdotal evidence from recent Canadian federal climate policy debates is consistent with this research. In the 2009 federal election, Stephen Harper claimed that Stephan Dion's carbon tax, with revenue recycled via tax cuts and energy transition assistance to lower income people, would ruin the economy. He furthermore claimed that he would achieve the same emissions reductions without ruining the economy by relying solely on regulations. Stephen Harper has a master's degree in economics. Whether or not he believed what he was saying, it appears that a significant segment of voters did. Then, in the 2011 federal election campaign, Harper claimed that because the NDP cap-and-trade proposal was a form of emissions pricing, it too was a carbon tax, and would thus have the same disastrous economic consequences. Again, he promised that his regulatory approach would be better for the economy for a given level of emissions reduction. Clearly, Harper understood the tendency for many members of the public to prefer regulations to pricing instruments. And his electoral successes ensured almost a decade of further delay in the implementation of effective climate policy by the Canadian government. (Of course, one cannot be sure, given the past track record, that electoral success by any of the other federal parties would have resulted in a materially different outcome in terms of climate policy effectiveness.)

Research into public perceptions and voter motives when it comes to climate policy is a rapidly expanding field of research, with most universities now having some focus on this topic.[16] Members of our research team have probed the British Columbia experience to produce a modest contribution to this literature. BC's government implemented a portfolio of climate policies in the period from 2007-2010. These included its carbon tax, along with a slate of regulations including a technology-neutral, zero-emission electricity standard, tighter energy efficiency regulations, a technology-neutral vehicle emissions standard, a low carbon fuel standard and a requirement for carbon neutral government. In a large survey, members of our research group tested the knowledge and views of British Columbians about these and other climate policies.[17] The survey found that knowledge about BC's climate policies was almost nonexistent. It also found that, once people learned about BC's current policies, most were more strongly supportive of regulatory policies, or at least had no negative views about these (less than 10% for each). In contrast, the carbon tax had just over 50% support, but opposition was far greater than for any other policy at over 40%. Views on cap-and-trade were intermediate: not as popular as regulations, but with less opposition than the carbon tax.

What inferences can we draw for Canadian climate policy design from these challenges to the 'rational model' of democratic policy-making? To be clear, we do not conclude that the Canadian government should abandon the economic efficiency criterion when designing climate policies. But we do argue that it is unhelpful to policy makers, in this case the Canadian government, to unnecessarily narrow their range of options to only those that have huge electoral risks. So we suggest instead that the government be cautious, indeed suspicious, when receiving climate policy advice from any interest group or entity

[15] See especially Caplan, The Myth of the Rational Voter: Why Democracies Choose Bad Policies, Princeton University Press, 2007.
[16] Some have more than one. Yale University has The Yale Program for Climate Change Communication and the Yale Cultural Cognition Project, both of which focus considerably on perceptions of climate science, economics and policy.
[17] See Rhodes, Axsen and Jaccard, "Does Effective Climate Policy Require Well-Informed Citizen Support?" Global Environmental Change, 2014.

that has an ideological pre-disposition to one particular climate policy approach.[18]

An obvious example is the EcoFiscal Commission. As its name suggests, this Canadian institution was created "to promote fiscal solutions" to ecological objectives such as GHG emissions reduction. Its mission statement and reports are laden with statements such as "ecofiscal solutions are essential" and "carbon pricing is an essential policy tool" and "carbon pricing is the most practical way." In its 2015 climate policy report, it purported to estimate the superiority of carbon pricing by contrasting four different policy scenarios.[19]

The 'ideal' scenario showed the effect of a Canada-wide carbon price with the carbon tax (or emission allowance auction) revenues recycled to maximize economic growth. This scenario is similar to repeated analyses done for the federal government by civil servants and independent experts (including one of us) since the late 1980s. The report's authors do not explore why the current Canadian government would implement this singular rising carbon tax in 2015 when previous governments for the past three decades had not done so. Nor do they address why recent modest efforts at emissions pricing in Quebec, Ontario and Alberta do not allocate emissions pricing revenues to maximize economic growth.

Moreover, in claiming to show the "cost-effectiveness of emissions pricing" the authors never actually compare emissions pricing with the flexible regulations that various jurisdictions have implemented to reduce GHG emissions, examples being the renewable portfolio standard applied by over half of the US states, or the vehicle emissions standards applied by California and 7 other US states, or the national coal plant emission regulations being implemented by the Obama administration. Instead, they compare 'inflexible' provincial or industry emissions targets with 'flexible' targets in which provinces and industries can trade or negotiate adjustments in their relative contributions to the aggregate reduction outcome. This is not a demonstration of the cost-effectiveness of emissions pricing.

In contrast to the approach of the EcoFiscal Commission, we suggest that an entity with a policy-neutral mandate (call it the 'Greenhouse Gas Reduction Commission') would recognize that trade-offs between economic efficiency and political acceptability must be considered, especially given that political acceptability constraints have repeatedly prevented effective climate policy. Thus one would assess the loss of economic efficiency due to regulatory policies whose primary design consideration was to maximize political acceptability, albeit while also trying to minimize economic efficiency costs through their 'designed-in' flexibility. To our knowledge, no EcoFiscal Commission report tackles this critical question. Hence our focus in this study.

Indeed, even if one is singularly stuck on economic efficiency as the only consideration for climate policy, one could argue that regulations may be the more economically efficient policy if they have a substantially higher probability of being implemented at sufficiently stringent levels. The economic analysis of the 2006 Stern report on the economics of climate change and greenhouse gas reduction illustrates this argument.[20] In the base case scenario of his report, Stern concluded that an economically efficient effort (global carbon pricing) to prevent average temperatures from increasing to dangerous

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[18] For further discussion, see Jaccard, "Want an Effective Climate Policy? Heed the Evidence," Policy Options, 2016.
[19] Canada's EcoFiscal Commission, The Way Forward: A Practical Approach to Reducing Canada's Greenhouse Gas Emissions, EcoFiscal Comission, 2015. See especially Chapter 4.
[20] Stern, The Economics of Climate Change: The Stern Review, Cambridge University Press, 2006. For an update of this type of analysis, see Nordhaus, The Climate Casino: Risk, Uncertainty and Economics for a Warming World, Yale University Press, 2013.

levels would cost about 5% of global GDP, and that failure to act would cause damages of 20% of GDP. If we enrich his analysis with information on the costs of alternative policy options and their probability of implementation, we may opt for policies that do not score highest in terms of economic efficiency, but instead have a much greater chance of political success. Say, for example, that effective levels of carbon pricing had only a 10 percent chance of political success in the period 2005-2020 while carefully designed, flexible regulations had a 90 percent chance. But the regulatory approach would cost 8 percent of global GDP instead of emissions pricing's 5 percent for the same level of emissions reduction. To stick with emissions pricing as the only option and therefore most likely incur a 20 percent loss of GDP from climate change would be economically inefficient compared with the likely successful application of regulations, even though these would be higher cost than emissions pricing. The probability-adjusted benefit-cost ratio of the regulatory approach is higher than that of the emissions pricing approach.

In this example, our relative probabilities for political acceptability and relative costs by policy type are purely illustrative. Our point is that this type of analysis should occur when evaluating Canadian climate policy options. The Canadian government should not yield to interests who lobby it to focus solely on economic efficiency if this means continued policy ineffectiveness because of the looming threat of political rejection. Instead, the government should assess the relative costs of all of its policy options in terms of all legitimate policy evaluative criteria. And it should be willing to trade-off among these criteria, all the while recognizing that effectiveness and political acceptability are essential given the information provided by scientists and economists about the global benefits and costs of significant, rapid greenhouse gas emissions reductions. We have to reduce emissions, which means that we must have effective policies that succeed politically. Political success, as any politician knows, involves a delicate balancing of the rational (the real distributional policy impacts) and the potentially irrational (incorrect perceptions of policy impacts).

Within this constraint, political leaders should of course seek to reduce emissions as efficiently as possible. This consideration is central to our proposed flexible regulatory policy package for Canada, which is one of the four scenarios that we explore in this report.

II. Contrasting Emissions Pricing with Flexible Regulations: Four Scenarios

II.1 Focusing on Policy Options of the Canadian Federal Government

We focus in this report on policies that only the Canadian federal government would implement. In other words, we assume that the federal government will fail in its endeavor to convince the provinces to voluntarily enact sufficiently stringent policies to achieve Canada's Paris commitment. We could be wrong. The period 2008-2016 has seen encouraging progress in provincial climate policies, in part to compensate for inaction by the Canadian government during the Harper era. According to enacted legislation, 30 out of 36 million Canadians will be under a carbon pricing policy in 2017, albeit at low prices ranging from $15 to $30. However, the climate policy with the greatest impact on emissions was Ontario's regulatory decision to ban coal-fired power plants, leading to an annual reduction of 27 Mt. Other regulatory policies have had more modest effects, although BC's zero-emission electricity requirement caused the cancellation of two coal-fired power plants and prevented a large gas-fired plant, reducing likely annual emissions by 10-15 Mt, three times the expected effect of its $30 carbon tax.

In spite of these encouraging signs, there is no indication that provinces will significantly increase emissions prices over the next few years. In their cap-and-trade program, linked with that of California, Quebec and Ontario have a set schedule for increases to the program's emissions allowance floor price such that this price will only grow slowly once inflation is accounted for. BC has frozen its carbon tax, meaning that it is declining in real terms (correcting for inflation). Alberta's tax is set to reach $30 in 2018, but the government has not indicated any increase to the tax after that. It is possible, with the falling emissions caps for Quebec, Ontario and California in the period after 2025, that the allowance trading price will rise above the floor price. But this is highly uncertain.

We also note that while the Canadian government has announced some climate policies, it has not yet laid out a policy package that it claims would achieve its Paris commitment. At this point, this is understandable because the government has been asking provinces to voluntarily implement sufficient policies. But it is important to estimate what effect these current and emerging federal policies are likely to have on national emissions, especially given the stated reluctance of provinces to take further actions and the unfortunate history of policy announcements by previous federal governments that were not backed by credible, independent assessments of their effect on emissions.

In this study, our four policy scenarios cover the period 2015 to 2050, with particular focus on 2030, which is the target year for Canada's Paris commitment to reduce national emissions 30% from their 2005 level. Emissions levels in 2050 are also of concern, however, given the research consensus that global emissions must fall significantly by mid-century if the average temperature is not to rise by more than 2 C by the end of this century. Moreover, while significant emission reductions may be possible in the 2030 timeframe, if we start immediately, much of the needed energy transition will occur after that date. This is why we continue our scenarios to 2050, with the assumption that policy stringencies will increase after 2030 at a rate comparable to their rate prior to that year.

II.2 Addressing Oil Price Uncertainty

In some countries, a high oil price makes it easier to reduce GHG emissions. Higher oil prices mean higher gasoline prices, which makes it easier to convince drivers to purchase electric, biofuel and perhaps hydrogen vehicles. In Canada, however, a higher oil price also increases the incentive to expand oil sands production, the most emissions-intensive industrial activity in the country. Thus, future oil prices will have a significant effect on Canada's ability to achieve its GHG targets, with high oil prices making it more difficult to reduce oil sands emissions and low oil prices making it more difficult to reduce oil consumption emissions.

We address uncertainty about global oil prices by simulating two versions of each policy scenario: a high oil price and a low oil price. The two oil prices are deliberately contrasted in order to explore the range of possible effects of oil price uncertainty.

We base the high oil price on a reference scenario from the National Energy Board.[21] In this scenario, the global oil price rises to US$80/barrel (bbl) in 2020 and US$100/bbl in 2040, resulting in an average Canadian gasoline price of $1.35/L (2010 CAD) in 2020 and $1.65 (2010 CAD) in 2040. We set oil sands output to rise from current production levels of 2.5 million barrels per day (mbd) to 6 mbd by 2030, holding constant thereafter at 6 mbd to 2050. In the low oil price version, we assume that the

[21] National Energy Board, Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040, National Energy Board, 2016.

global price of oil stays constant at US$50/bbl to 2050, resulting in an average Canadian gasoline price of $1.15/L throughout the simulation. We hold oil sands output constant at today's level of 2.5 mbd.

Table 1: Two Versions of the Global Oil Price and Alberta Oil Sands Production

Oil Price	Oil Price Trajectory (Western Texas Intermediate: $/bbl, 2010 USD)	Gasoline Price Trajectory (Canadian average: $/L, 2010 CAD)	Oils Sands Output (million barrels/day)
High Oil Price	Rises steadily from today's price to $80 in 2020 and $100 in 2040	Rises steadily from today's price to $1.35 in 2020 and $1.65 in 2040	Rises steadily to 6 mbd by 2030, then stays constant to 2050
Low Oil Price	Remains at $50 up to 2050	Remains at $1.15 up to 2050	Remains at today's 2.5 mbd up to 2050

II.3 Business-As-Usual (BAU) Scenario

The business-as-usual (BAU) scenario assumes no significant increases in the stringency, and therefore effectiveness, of existing climate policies in Canada, be these federal, provincial, territorial or municipal. Again, given the history of government announcements without subsequent policy implementation, we believe that independent researchers such as ourselves should only give governments credit for those policies to which they are politically committed, having either passed legislation or implemented tax changes. Only in a few cases do we give governments credit for policies that have not yet been fully implemented because in these cases the government has demonstrated a strong commitment to following through, having already faced considerable political challenges in doing so.

Here is a summary of the policies in our BAU scenario:

- **Federal:** We include the federal light-duty and heavy-duty vehicle emissions standards, which set minimum emissions standards for vehicles up to 2025, as well as the coal performance standard, which requires new and end-of-life plants to meet an emissions-intensity standard equivalent to natural gas plants (in essence requiring end-of-life coal plants to either shut down or retrofit with carbon capture and storage technologies).
- **British Columbia:** We model the carbon tax that rose to $30/tCO_2$ by 2012, and is now frozen (and thus declining after correcting for inflation). We also model the clean electricity regulation, which was recently updated to require 100% of electricity generation in the province to be from clean or renewable electricity (with allowances to address reliability)
- **Alberta:** We model the existing Specified Gas Emitters Regulation (SGER), which requires large industrial emitters to meet increasing intensity standards or pay a price for emissions above the standard. By 2017, the regulation requires a 20% reduction in emissions intensity and a price of $30/tCO_2$ over the standard. We also model the recently announced Climate Leadership Plan, which includes: a carbon levy on all combustion fuels used outside of industry, rising to $30/tCO_2$ by 2018 (with no commitment to increase it thereafter); product and sector-based industry performance standards, which are still under development to replace the SGER (we

approximate these as a $30 emissions price); a phase out of all coal electricity generation by 2030; a commitment to replace two-thirds of phased-out coal capacity with renewable energy capacity; a performance standard for oil sands operations in the high oil price future to ensure that oil sands emissions remain under the 100 Mt cap (a performance standard is not required in the low oil price future as oil sands emissions remain under 100 Mt without policy); and regulations to reduce methane emissions from oil and gas operation by 45% by 2025.

- **Saskatchewan:** We model the Boundary Dam coal power plant carbon capture and storage retrofit and the recently announced target of 50% renewable electricity capacity by 2030.
- **Manitoba:** We model the phase out of coal electricity generation that was completed in 2010.
- **Ontario:** We include the province's recently announced cap-and-trade policy, which will begin in 2017 and will be linked to the Quebec and California cap-and-trade system. We also model the phase out of coal electricity generation that was completed in 2014, and the province's feed-in-tariff that offered fixed contract prices for renewable generation and is being transitioned to include a procurement process for larger renewable electricity projects.
- **Quebec:** We model the $3 carbon tax that began in 2007, and the subsequent cap-and-trade system that started in 2013 and was linked to California's cap-and-trade system in 2014. We also include the recently announced zero-emissions vehicle mandate, which once passed will require automakers to sell a minimum number of near zero-emissions vehicles, increasing to 15.5% of sales by 2025.
- **Atlantic:**[22] We model Nova Scotia's declining electricity sector emissions cap, which required the combined emissions of all electricity-producing facilities in the provinces to be no greater than 4.5 Mt CO_2 by 2030, as well as the province's renewable portfolio standard, which requires a minimum of 40% renewable generation by 2020.

Also included are all provincial and federal low carbon and renewable fuel standards, energy efficiency standards in provincial building codes, federal energy efficiency standards for energy-consuming technologies, and provincial landfill gas regulations. We have not modeled subsidy and incentive programs, as these do not guarantee emissions reductions, are prone to high levels of free-ridership (i.e. subsidies are claimed by those who would have purchased the technology even in the absence of the subsidy), and often only last for limited durations.

Finally, we note that we have chosen to model in-province emissions reductions from the Quebec and Ontario cap-and-trade policies, but not purchases of emissions reduction allowances from California, their non-Canadian allowance trading partner. We model the policy as a carbon price rising in line with the policy floor price, which began at $10.75 in 2013 and increases at an annual rate of 5% plus inflation. We set the price at 10% above the floor price, as this has been the average trading price over the past three years, and we assume an ongoing exchange rate of 1 CAD = 0.75 USD. Our chosen approach provides our best estimate of the evolution of emissions actually produced in Canada. While we cannot be sure what reductions will occur within the boundaries of each of the three emissions trading partners (since it depends on the interplay of their different targets and reduction costs), the evolution of the allowance trading floor price provides one plausible indication of the carbon emissions

[22] While we acknowledge the unique characteristics and circumstances of each Atlantic province, they are grouped together in the model and our analysis due to the fact that they are grouped together in Natural Resource Canada's Comprehensive End Use Database, which serves as a key data source for our model.

price trajectory, which in turn will determine emission reductions in the two Canadian jurisdictions.[23] The three subsequent scenarios build on the BAU scenario, meaning that their policies are modeled in addition to the already existing policies from the BAU scenario.

II.4 Federal Climate Policies as of August 2016 (Fed-Aug2016) Scenario

Our second scenario estimates the likely incremental effect of climate policies that the new Canadian government has pursued since its election in late 2015. Thus far, the government has emphasized the promotion of investment in low-emission energy and technology as key to its climate strategy.[24] The federal budget of March 2016 contains a variety of funding commitments that fall under this umbrella. In this case we model subsidies and public investments in order to demonstrate to what degree they will likely contribute to the federal government's emissions reduction commitment. While we do not yet have full details on how all of the funding will be used over the course of the next several years, we made the generous assumption that the majority of it will go to actual investment in technologies (as opposed to government overhead costs) and that the funding will be targeted at technologies that have the potential to lead to substantial emissions reductions.

To represent the federal budget funding commitments, we modeled subsidies targeted to low emission technologies in residential and commercial buildings, electricity generation, and oil and gas, to represented possible uses of funding commitments such as the $2 billion low carbon economy fund, $50 million for cleaner oil and gas technologies, the $125 million Green Municipal Fund, $2.1 billion in funding for federal infrastructure investment (including 'greening' government operations), and the $2 billion Post-Secondary Institutions Strategic Investment Fund (which includes funding for reducing GHGs at universities.) We also included subsidies to electric vehicles to represent investment in alternative fuel infrastructure. We modeled the $3.4 billion Public Transit Infrastructure fund as a 2% increase in national transit ridership, a very generous assumption given past trends of ridership increases in Canada with transit investment, and based on the fact that ridership rates in the majority of European countries remain low in comparison to vehicle use despite better funded and developed transit systems. We did not model funding targeted at clean tech innovation, research and development, and demonstration. While innovation can be valuable, this funding does not guarantee any technological breakthrough that will reduce emissions.

Aside from the budget, the only key policy the federal government has announced since the 2015 election is its intent to regulate methane emissions from the oil and gas sector in partnership with the United States.[25] We modeled this policy through increased use of methane leak detection and repair in the oil and gas sector, in order to achieve the stated goal of reducing methane emissions in the oil and gas sector by 40 to 45 percent below 2012 levels by 2025.

The federal government's complete climate strategy has yet to be unveiled. The federal government has held public consultations on its strategy over the past several months, and a series of working groups – initiated through collaboration among the federal and provincial governments at a First Ministers

[23] The issue of possible allowance purchases from California is explored in Sawyer, Peters and Stiebert, Impact Modeling and Analysis of the Ontario Cap and Trade Program, Navius Research Consulting and EnviroEconomics, 2016.
[24] Canada's Way Forward on Climate Change http://www.climatechange.gc.ca/default.asp?lang=En&n=72F16A84-1
[25] "Reducing methane emissions from Canada's oil and gas industry." http://news.gc.ca/web/article-en.do?nid=1039219

meeting this past March – are set to report back this October.[26] While we cannot know exactly what the federal government's strategy will entail, the government has stated its intention to establish a minimum national carbon price. The government has thus far provided no indication of what that level would be, but at no time has it talked of exceeding the floor price of the cap-and-trade system in Ontario and Quebec. In this scenario, we assumed a minimum national price of \$15/tCO_2 in the 2017-2020 period, rising by \$5 every five years thereafter (thus reaching \$25 in 2030). Where an existing provincial carbon pricing policy from the BAU scenario exceeds the minimum national price, the provincial price is used to represent our assumption that provincial governments will continue on their current paths.

Finally, we note that we provide this scenario in order to show the likely incremental effects of government initiatives in the year since its election. While the government is not claiming that these policies dramatically reduce emissions, we felt it is important to have an independent assessment of the likely effect of the policies that have been presented thus far.

II.5 Emissions Pricing Scenario

Our third simulation relies on a steadily rising economy-wide emissions price that achieves Canada's Paris commitment for 2030 and continues to affect emissions thereafter in line with Canada's 2009 Copenhagen commitment to reduce national emissions 65% by 2050. The carbon price was simulated in place of, rather than as additive to, the weaker carbon pricing policies in the previous two scenarios, and it is applied to both fossil fuel combustion emissions and non-combustion industrial process emissions. Our carbon price could represent either a carbon tax or a cap-and-trade system.

In the case of the carbon tax, we assume that the tax revenues are redistributed in ways that minimize policy-induced transfers among provinces, industrial sectors and individuals. Thus, lump sum rebates of some form could be used to ensure that the distributional effects are minimized without distorting the carbon tax price signal when governments, firms and households make investment and operating decisions involving energy forms, technologies, buildings, and infrastructure. In the case of cap-and-trade, auctioning of emission allowances would create revenues that, again, we assume would be redistributed in the same manner as those from the carbon tax. Alternatively, government could grandfather allowances to certain industries and individuals to reduce distributional impacts.

An important consideration when adopting stringent climate policies is whether or not other countries are adopting policies of similar levels of stringency. If Canada adopts stringent policies but other countries fail to do so, we could see substantial leakage, which would involve (1) high-emitting firms relocating to countries with weaker or no policies, and (2) trade substitution of cheaper products from countries with weaker policies for Canadian products that would be now somewhat more expensive due to climate policy. This leakage could be reduced, however, if Canada adopts trade measures to protect domestic industries, such as by applying carbon tariffs on imports from countries with weak climate policies. Leakage would not be a concern if all countries are acting in concert and there is no relative difference in carbon pricing or regulatory stringency. In our scenarios, we assume that Canada is somewhat, but not dramatically, ahead of key trading partners, and that, where necessary, it implements policies to reduce leakage effects.

[26] *Communiqué of Canada's First Ministers*: http://pm.gc.ca/eng/news/2016/03/03/communique-canadas-first-ministers

II.6 Flexible Regulations Scenario

Our fourth scenario focuses on the application by the federal government of a set of flexible regulations that would play a key role in driving the Canadian energy transition to achieve the 2030 and 2050 GHG commitments. While these regulations are especially important over the next 15 years, and are thus a substitute for a rapidly rising emissions price, they also set the stage for more aggressive emissions pricing in the period after 2030. In that period, the flexible regulations and emissions pricing act as complements rather than substitutes, once the regulations have ensured a greater market visibility, and lower costs, for key low- and zero-emission technologies and energy forms.

Emissions pricing advocates often compare their preferred policy with ‘command-and-control’ (also called ‘prescriptive’) regulations. These types of regulations are indeed likely to be much less cost-effective than emissions pricing. The reason is that they prescribe the universal adoption of specific technologies or energy forms with no recognition of the diversity of households and firms, and thus the diversity of costs imposed by the regulation. Such regulations are also based on the premise that government is best at picking technology and energy winners, and they do not provide strong incentives for innovations that reduce emissions in unexpected ways.

An example of a prescriptive regulation would be one that required all vehicles sold in 2020 to be powered by hydrogen fuel cells, with the hydrogen produced via electrolysis. This outcome is technologically possible. But it rules out the possibility that electric and/or biofuel vehicles will be a cheaper option for achieving the same environmental goal. And it pays no heed to the costs of reducing vehicle emissions relative to the costs of reducing emissions from other sectors of the economy.

While command-and-control regulations may have advantages in certain situations, alternative flexible regulations would generally offer a higher degree of economic efficiency, which if carefully designed might even come close to the economic efficiency of emissions pricing policies. One type of flexible regulation would be an average sectoral emissions performance standard, such as a requirement for declining average emissions per tonne of steel from the entire the steel sector. While each firm would face fines for not meeting the industry average, it could avoid these fines if it showed that it had contracted with another firm to exceed the average, thereby offsetting its failure to comply. Thus, government would leave it to industry to determine how to meet the sectoral performance standard – letting the industry decide collectively whether to establish some form of trading scheme or to simply let individual firms contract bi-laterally (which might be the cheapest option in a sector with few players).

Another type of flexible regulation can be referred to as a niche market regulation. Such a regulation would require an initially small but growing market share for potentially transformative low emission technologies that would otherwise have difficulty competing with higher-emitting conventional technologies. An example is a partial-zero-emission vehicle (PZEV) standard that requires vehicle manufacturers, on average, to achieve a rising market share for any combination of low- and zero-emission vehicles. This includes plug-in hybrids, pure electrics, hydrogen fuel cells, and vehicles running mostly on biofuels.

Such a policy can help manufacturers and consumers minimize the costs of reducing emissions. Manufacturers can be allowed to trade compliance obligations to reduce costs. In competition with each other, they must develop and market vehicles that are the most attractive to consumers because of relative cost, performance and other attributes – leaving the technological solutions to be determined by traditional competitive market forces. As part of this effort, manufacturers might increase the price of luxury vehicles (whose consumers are least responsive to higher prices) in order to lower the prices of PZEVs to ensure compliance with the sales quotas required by the policy. Finally, government can adjust the PZEV obligation in future years as it learns over time about the costs of GHG emissions reduction in transportation relative to other sectors of the economy.

This type of policy is not an untested experiment. In fact, a more detailed version, that distinguishes a range of low- and zero-emission vehicles, has been in operation in California for years.[27] It is widely seen as the reason California leads the world in the adoption of low emission vehicles. Seven other states, and most recently Quebec, have adopted some form of the policy. The Canadian government is certainly capable of doing the same. Moreover, a Canada-wide, flexible regulation in the personal vehicle sector would have no regional implications. Impacts would be virtually the same right across the country. This is a case where federal action is preferred to provincial action.

Flexible regulations may be especially advantageous if, as the survey data suggests, they outperform emissions pricing in terms of political acceptability, particularly at the start of the transition to a low carbon economy. Flexible regulations avoid rapid increases in, for example, the price of gasoline, while nonetheless ensuring that the necessary low- and zero-emission technologies and energy forms begin now to penetrate the market, albeit initially in limited applications. Over time, the regulations should help bring down the barriers to adopting low emission technologies and energy forms by: (1) driving innovations that decrease the production costs of low-emission technologies, (2) increasing public familiarity with low-emission technologies and thus reducing perceptions of risk, (3) stimulating increasing demand for low-emission technologies so that manufacturers can enter into mass production which lowers cost, and (4) fostering the development of supporting infrastructure needed to support the adoption of low emission technologies (such as biofuel refueling at gasoline stations and electric rechargers at apartments and offices). With these barriers lowered and low emissions technologies increasingly seen as viable options in technological and financial terms, the regulations should pave the way for increased political acceptability of higher carbon prices in the 2030 to 2050 timeframe.

This is why this scenario depicts regulations and emissions pricing as substitutes in the near-term, but complements in the long-term. The emissions price in this scenario is kept low in the earlier years, but rises later. It starts at $25/tCO_2$ in 2021, rising to $40 in 2030 and $100 in 2050 (all in 2016$). Along with this carbon price, we model a package of regulations in the electricity, transportation, and industrial sectors designed to meet the 2030 commitment while minimizing economic inefficiencies and offering protection to trade-exposed industries. We focus on these sectors for illustrative purposes and to keep the list of regulations focused. However, we expect that similar policies for buildings, waste, and agriculture would also play a role in a more comprehensive regulatory package.

Electricity

In the electricity sector, we propose a regulation that requires the elimination by 2030 of all coal-fired electricity generation that does not have carbon capture and storage. This regulation builds on the federal government's regulation for new and end-of-life coal plants by also requiring coal plants that have not reached end-of-life by 2030 to either close or retrofit to carbon capture and storage technologies. Since

[27] See Jaccard, "Effective climate change regulations: Let's transform Canadian cars." Policy Options, 2016.

coal-fired electricity generation is a large contributor to emissions and technologically feasible alternatives are readily available, we believe that this is one area where a somewhat inflexible regulation is appropriate. Additionally, however, we apply a near-zero emission flexible electricity standard, which requires provinces to generate a given percentage of electricity from near-zero and zero-emission sources. In provinces that currently rely on hydro generation (British Columbia, Manitoba, Quebec, and Newfoundland), our performance standard requires 100% zero-emission electricity generation by 2030. In provinces that currently rely more on fossil fuels and lack large hydropower options (Alberta, Saskatchewan, Ontario, New Brunswick, Nova Scotia, Prince Edward Island, and the territories), our performance standard requires 90% zero-emission electricity generation by 2030. Coal plants with carbon capture and storage would fall under the zero-emissions category in proportion to the rate of emissions captured. Our proposed electricity regulation would also apply to electricity generated through cogeneration in industry, thus preventing avoidance of the regulation through substituting high-emitting industrial generation for utility generation.

The differentiated standard is designed to reduce distributional effects among the provinces. Provinces currently more reliant on fossil fuel generation, and that have less hydro power potential to exploit, will be required to take significant actions to reduce emissions. But their standard is somewhat less stringent in recognition that they lack low-cost hydropower reservoirs for insuring the reliability of electricity from intermittent renewable sources. Jurisdictions without large hydro reservoirs may find it costly to develop energy storage options other than natural gas stand-by plants as the means for ensuring reliability as more intermittent renewables enter the supply mix.

Personal vehicle transportation

In the personal transportation sector, we propose, as noted above, a partial-zero-emission vehicle (PZEV) mandate. The policy requires vehicle manufacturers, on average, to meet a minimum aggregate PZEV sales requirement of 5% by 2020, 35% by 2025, 70% by 2030, and 100% by 2040. Eligible vehicles include pure electric vehicles, plug-in hybrid electric vehicles, hydrogen fuel cell vehicles, and flex-fuel vehicles that can fill up with ethanol-85. A potential concern with including ethanol-85 flex-fuel vehicles in the regulation is that these vehicles could be sold but continue to fill up on conventional gasoline. In the same vein, ethanol flex-fuel vehicles were initially a compliance loophole in the US vehicle emissions standards.[28] However, this was corrected by only giving flex-fuel vehicles credit in proportion to the percentage of such vehicles actually filling up with ethanol in the country, which can be estimated from national ethanol sales statistics.[29] Following this approach, our proposed vehicle policy only gives credit to flex-fuel vehicles in proportion to the amount that such vehicles use ethanol as a share of their annual fuel use, as estimated from gasoline, ethanol and vehicle sales data.

We also propose a Low Carbon Fuel Standard (LCFS) governing the energy used by vehicles in Canada, similar to the policies that now exist in California and BC. The LCFS requires fuel distributors, on average, to meet a growing percent of low carbon fuel sales, equal to 10% low emission fuels by 2025, 40% by 2030, and 90% by 2040. Ethanol-85 qualifies as a low carbon fuel, and would likely be cross-subsidized through a small increase in gasoline prices to bring its cost slightly below that of gasoline,

[28] Davis, L. (2016). "Automakers complain, but CAFE loopholes make standards easier to meet." Energy Institute at Haas. https://energyathaas.wordpress.com/2016/04/11/automakers-complain-but-cafe-loopholes-make-standards-easier-to-meet/
[29] EPA. "EPA and NHTSA set standards to reduce greenhouse gases and improve fuel economy for model years 2017-2025 cars and light trucks." https://www3.epa.gov/otaq/climate/documents/420f12051.pdf

encouraging its use by flex-fuel vehicle drivers. To enable full energy choice neutrality, fuel distributors could also purchase credits from electricity utilities based on data from smart meters on electric and plug-in hybrid vehicle owners recharging their vehicles, or from hydrogen fuel distributors.

Freight truck transportation

In the freight truck sector, our proposed regulations for inter- and intra-city trucks follow a somewhat differentiated design in comparison to the personal vehicle regulations. Due to the larger loads and longer distances travelled by freight trucks, particularly heavy-duty intra-city trucks, electric freight vehicles face greater barriers. Moreover, the development of biofuel applications would likely differ in the two sectors. Vehicles require engine modification to run on high blends of ethanol, which is likely to be the key biofuel candidate that could replace gasoline for personal vehicles. On the other hand, most trucks do not require engine modification to run on a high blend of hydrogenation-derived renewable diesel (HDRD), which could become a key biofuel candidate to replace diesel for trucks. HDRD could simply be blended with conventional diesel in increasing quantities over time, without the need for new refuelling infrastructure or new truck engines. (Biodiesel, which is chemically different from HDRD and would require engine modification at higher blends, may also play a role. But for simplicity we have chosen to presume the dominance of HDRD.) Rather than a PZEV standard, we propose a truck emissions standard that has greater stringency in comparison to the current federal vehicle emissions standards. We also run a LCFS that is similar in design to that of the LCFS in personal vehicles, and requires fuel distributors to meet a minimum low carbon fuel sales requirement of 20% by 2025, 40% by 2030, and 80% by 2040. Again, flexibility can be achieved through the purchase of credits from electricity utilities, hydrogen fuel distributors, and perhaps to a smaller degree liquefied and compressed natural gas vehicle fuel distributors (since natural gas has a lower carbon intensity compared to diesel).

Buses and rail

We also propose regulations to reduce emissions from buses and rail. For urban public transit buses, inter-city buses, passenger trains, and freight trains, we require new market share of buses and trains running on diesel or other fossil fuels to fall to zero within the 2030 to 2035-time period. The regulations are flexible in the sense that any combination of electricity, biodiesel, hydrogen, or other low carbon fuels could replace conventional diesel and other fossil fuels. While we do not propose regulations for airplanes and ships, due to complications related to their exposure to international leakage, we believe that in the long-term regulations would also be needed to spur emissions reductions in these areas of transportation.

Biofuel and hydrogen production

To mitigate upstream emissions from fuels used in the transportation sectors, we also modeled performance standards for biofuel and hydrogen-fuel production. (Our electricity regulations already cover upstream emissions for any electric-power transportation.) The performance standards drive all ethanol, HDRD, and hydrogen fuel production to near-zero emission levels by 2030. This can be achieved by switching to production processes that do not use fossil fuels, such as biodiesel tractors for production of biofuel feedstocks, biomethane or electric boilers for biofuel production plants, and electrolysis for hydrogen production. While some nitrous oxide emissions are associated with biofuels as a result of agricultural production of feedstocks, we calculate that production emissions could be driven to below 15% of the current per-litre production emissions of conventional gasoline and diesel. We also assume that policy checks are in place to minimize emissions from land-use change caused by biofuel production, such as would occur if forests were cut down to clear land to grow corn for ethanol. Given Canada's vast landmass, including underutilized agricultural land, we believe that biofuel production can occur without substantial land-use loss or cost increases for food production.

Industrial sectors

For industry we propose sector-specific performance standards starting in 2020 that set declining percentage emissions intensities, measured as GHG emissions per unit output. Industries have to meet a targeted intensity or pay a fee for any emissions above this standard. The policy is flexible, however, in that a sector would only have to achieve these emission intensities on average. Facilities within the sector that already have emissions below the intensity requirement, or find it relatively easy to reduce their intensities, would be given permits for every unit below the standard, which they could sell to facilities that find it less costly to buy a permit rather than reduce their emissions intensity.

Within our model we do not apply these performance standards uniformly across all industry. We designed the policy to ensure that sectors that are trade exposed and carbon intensive would be protected by having less stringent standards. These include: chemical products, iron and steel, petroleum refining, natural gas extraction, and petroleum crude production. Sectors that do not get this stringency reduction include: coal mining, industrial minerals, metal smelting, mining, other manufacturing, pulp and paper, biodiesel, and ethanol. Finally, since permits are only allocated and required for differences from the targeted emissions intensity, there is not a substantial emissions pricing cost to factor in to industrial production costs.[30]

Finally, the performance standard we propose for the Alberta oil sands differs from that which we apply to other industrial sectors. A 100 Mt emissions cap on oil sands has already been promised by the Alberta government, and we found that is was not necessary to apply additional more stringent federal policies on this highly trade-exposed industry in order to meet the 2030 target. However, we propose that a federal performance standard should be applied after 2030 that drives deeper decarbonisation reaching low emissions levels by 2050.

III. Modeling Method

Analysts apply energy-economy models to estimate the likely impact of policies focused on the transition to low- and zero-emission energy options. 'Computable general equilibrium' (CGE) models have some sectoral and technological details, but especially focus on the macro-economic links between private and public investments and expenditures, and government budgets, making them ideal for modeling the revenues and expenditures triggered by an economy-wide carbon tax. In contrast, 'hybrid energy-economy' models have some macro-economic feedbacks, but especially represent the technology acquisition decisions of firms and households in energy demand sectors (vehicles, buildings, energy consuming industries) and energy supply sectors (oil, gas, electricity, renewables). While CGE models are good at estimating the GDP effects of emissions pricing policies, hybrid models are good at estimating the effect of technology- and sector-specific policies designed to regulate or otherwise influence technology and energy choices.

[30] This policy has similarities to the emissions intensity policy applied to large industrial emitters in Alberta since 2005.

Given that our key scenario involves technology- and sector-specific policies, we opted to use a well-known hybrid energy-economy model to simulate our four policy scenarios. This model, called CIMS, was developed by researchers in our institute over the past three decades, but is now widely used across Canada and in other countries.[31] It has similarities to the NEMS model used by the US Energy Information Administration to estimate the effect of energy-climate policies in that country.

CIMS simulates technology and energy choices based on conventional and less conventional investment attributes. Conventional attributes include capital cost, non-energy operating cost, energy cost, and time preference. Less conventional attributes include technology- and energy-specific risks and firm and household intangible preferences, as estimated from revealed data (historical market decisions) and stated data (survey responses when asked hypothetical question – about for example an electric car), or as estimated through expert judgement.

The CIMS model is especially appropriate for simulating flexible regulations because it explicitly represents each key energy decision 'node', such as the choice of personal vehicle fuel, which itself might be embedded within another node, such as the choice of transit versus personal vehicle for urban mobility. Within these decision nodes, the model user can simulate the effect of a flexible niche market regulation by forcing an increasing market share for a group of technologies without specifying the outcome of competition between these. The user requires the aggregate market share of PZEVs to increase, but competition between the various PZEV options (electric, hydrogen, biofuel) determines their individual shares within that aggregate.

CIMS is also designed to pick up dynamic feedbacks that reflect how financial costs and intangible factors may change over time. As new technologies pass market thresholds, their costs of production fall to reflect economies-of-scale in manufacture and more intensive innovation. At the same time, as new technologies gain market share, a 'neighbor effect' function in the model reflects how resistance to new technologies decreases because potential consumers become more familiar and confident with the product as more neighbors and friends adopt it.

Since CIMS keeps track of the costs of reducing GHGs, it can also guide efforts to equilibrate the costs of reduction among sectors and regions. If costs per unit of GHG reduced are found to be higher in one sector than another, it is possible to relax the rate at which regulations become stringent in the higher cost sector, thereby shifting costs in an effort to approximate the equivalency of reduction costs (at the margin) that is a cost-effective benefit of economy-wide emissions pricing.

However, while CIMS offers these strengths as a policy simulation tool, it lacks the ability to estimate the broader macro-economic effects where government policies change the tax regime. Thus, if governments apply a carbon tax, CIMS can simulate the emissions effect of the carbon tax, but it cannot show the relative GDP effect of alternative revenue recycling schemes, such as income tax cuts, lump sum payments, subsidies to energy transition investments, and public infrastructure investments. In using CIMS in this exercise, therefore, we assume for expediency that government recycles carbon tax revenues (and other climate related charges) so that redistribution effects among regions, sectors and individuals are minimized. Often, for political acceptability reasons, this assumption is valid.

[31] For details on key CIMS algorithms and assumptions, see Jaccard, "Combining top-down and bottom-up in energy-economy models," in Evans and Hunt (eds.), International Handbook on the Economics of Energy, Edward Elgar, 2009.

CIMS is also less effective than a CGE model at estimating structural effects as climate policies increase the costs in some sectors more than others. The version of the model that we apply in this project does estimate some structural change in response to changing relative costs of production, but this factor is incomplete compared to a typical CGE model. We note again, however, that in designing climate policies governments seek to minimize structural effects on the economy. As we note in our policy descriptions, this goal has also guided our application of the flexible regulations policy scenario.

Since CIMS underrepresents structural and GDP changes resulting from climate policies, especially as these policies become more stringent, it exaggerates the emissions price necessary to achieve a given level of emissions reductions. In other words, emissions fall under a rising carbon price because people switch fuels and use less energy, and CIMS captures this. But emissions also fall because emissions-intensive industries and activities, and even total economic output, decline. With its partial view, CIMS might show that a tax of \$100/tCO_2 is needed for a 20% emissions reduction. With a full equilibrium view, a CGE model might show that only \$85/tCO_2 is needed for the 20% reduction, because that model includes the additional, simultaneous reductions caused by structural and output changes.

Fortunately, our modeling team has considerable experience using CGE models and CIMS, both alone and in tandem. Based on this past evidence, we adjust our CIMS carbon price estimates to correct for this missing modeling element, indicating both the initial CIMS estimate and our adjusted value.

IV. Modeling Results

IV.1 National Results

In our BAU scenario, the results show little progress towards achieving the 2030 Paris commitment (30% reduction), with emissions levels at only 4% below 2005 levels. This is not to say that current policies are having no impact on reducing emissions. Due to economic and population growth, Canada's emissions would likely be on a path to exceed 2005 levels in 2030 in the absence of current policy measures.[32] However, current measures are far from sufficient to meet Canada's 2030 commitment. Furthermore, by 2050, the BAU scenario shows emissions reductions of 0 to 6% relative to 2005 levels, far from the deep reductions needed by countries like Canada if humanity is to prevent temperatures from rising by more than 2 C in this century.

Emissions are slightly lower under the high oil price by 2050, as increasingly high gasoline and diesel prices drive a greater degree of fuel switching in transportation in comparison to the low oil price. Meanwhile, Alberta's provincial policy of a 100 Mt emissions cap for the oil sands prevents a large increase in emissions under the high oil price, despite much higher oil sands production.

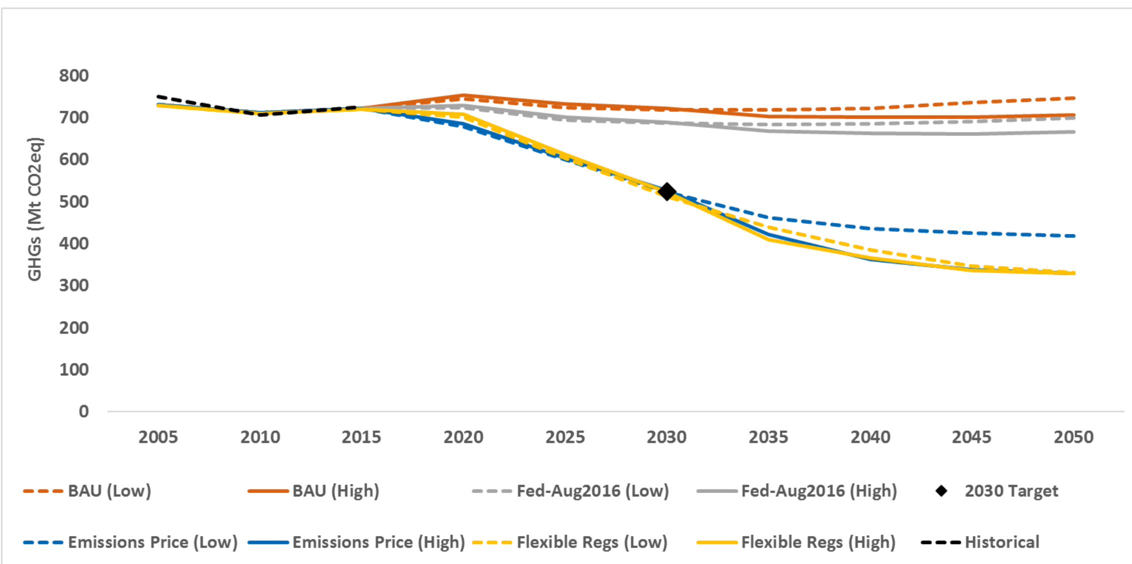
In our federal policies as of August 2016 scenario (Fed-Aug2016), national emissions fall to 8% below 2005 levels by 2030, and to 7 to 11% below 2005 levels by 2050. These results are only a small improvement over the BAU scenario and again far from sufficient to meet Canada's 2030 commitment. The low carbon price we model to represent our best guess at the federal government's intended minimum carbon price is far too low to drive the necessary emission reductions. As for the government's investments and subsidies to low carbon technologies, our model shows high free-

[32] Environment Canada. Canada's Emissions Trends 2014.

ridership rates, exceeding 50% in most cases. This means that subsidies go towards technologies that were already being adopted in the BAU simulation, due to a combination of other policies and the heterogeneous market choices of consumers and industry. The recently announced federal methane emissions regulation for the oil and gas sector drives some emissions reductions, but mainly in British Columbia and Saskatchewan since the provincial Alberta methane regulations are already in the BAU scenario. On the whole, this representation of the federal government's intended climate strategy – based on policy announcements and statements of policy intent – is inadequate to meet Canada's targets. Again, we understand that the federal government acknowledges this, which is why it continues to develop climate policies on its own and potentially in concert with the provinces.

In contrast with the first two scenarios, our second two are designed to achieve the Paris commitment. In the emissions pricing scenario, we simulated increasingly higher carbon price paths until we found one that achieved the necessary 30% reduction. In the flexible regulations scenario, we had set our key regulations to follow a similar national emissions trajectory, albeit with some sectors contributing more and some less than under the carbon pricing scenario. Figure 1 presents the national emissions under each scenario.

Figure 1: National GHG Emissions



N.B. *Low = low oil price, High = high oil price.*

Figure 1 also shows that emissions continue to fall after 2030 under the emissions pricing and the flexible regulations scenarios to reach 45% to 55% below 2005 levels by 2050. While this trajectory fails to achieve the 65% reduction that Canada committed to at Copenhagen in 2009, at least the gap is not enormous. If necessary, slight increases post-2030 in the carbon price path or the stringency of the flexible regulations should enable the country to achieve the 65% target.

Figure 2 shows the carbon price paths for the emissions pricing scenario and flexible regulations scenario, with high and low oil price assumptions. In our carbon price scenario with high oil prices, the carbon price (in \$2015) must rise to \$250/tCO_2 by 2030 in order to meet Canada's Paris commitment.

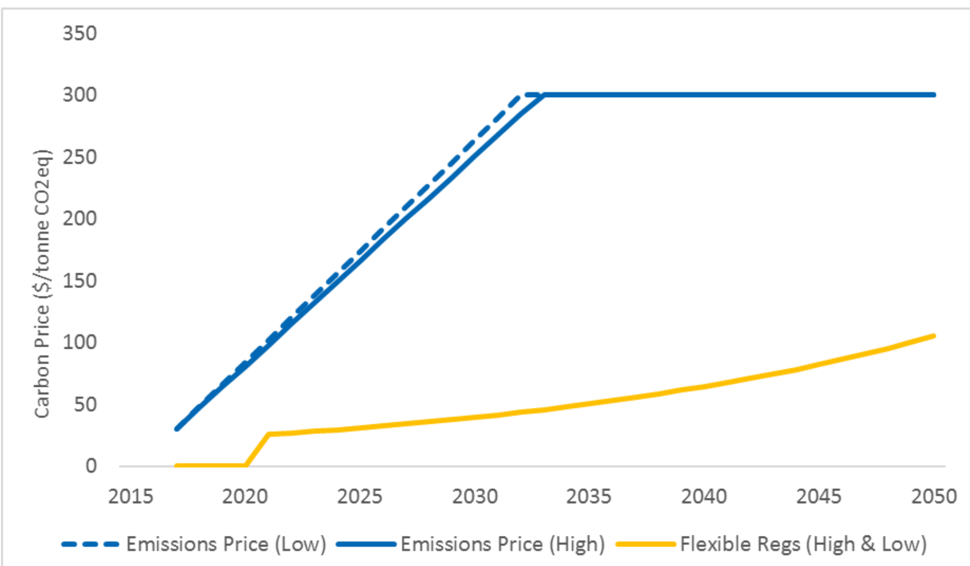
With low oil prices, the 2030 carbon price is slightly higher at $265. This means that the carbon price must increase by about $15 per year.

While this carbon price path might seem unbelievably high, it is consistent with the findings of other researchers. Using a CGE model, Bataille and Sawyer recently estimated that Canada would need a carbon price of $110 by 2030 just to reduce emissions to 15% below 2005 levels.[33] Clearly, the additional reductions required to be 30% below would require a much higher carbon price.

As noted, however, the carbon price path we estimate using just the CIMS model is likely an overstatement of the required carbon price path because the model, used by itself, under-represents the full macro-economic response. Based on previous joint applications of CIMS with a CGE model, we believe that the more likely 2030 carbon price would need to be adjusted downward by about $50, to $200 in 2030 with high oil prices and $215 with low oil prices.[34]

While there is uncertainty about the precise carbon price to reach the Paris commitment, there is no uncertainty that this price will be extremely high relative to what has thus far been politically acceptable during three decades of climate policy efforts. In that regard, it is interesting to contemplate the electoral prospects of a government that increased carbon taxes by $15/tCO_2$ each and every year – while trying to convince the public that it was giving all of the tax revenue back to Canadians in ways that would help them personally and the economy as a whole.

Figure 2: Carbon price under emissions pricing and flexible regulations scenarios



N.B. Low = low oil price, High = high oil price.

Figure 2 also provides the carbon price path in our flexible regulations scenario. Our carbon price path

[33] Bataille and Sawyer, "Canadian carbon pricing pathways: The economic and emissions outcomes of leading policies." EnviroEconomics, 2016. http://www.enviroeconomics.org/single-post/2016/09/06/Assessing-Canadian-Carbon-Pricing-Pathways

[34] See, for example, Peters, Bataille, Rivers and Jaccard, "Taxing emissions, not income: How to moderate the regional impact of federal environment policy," CD Howe, 2010.

in the case of flexible regulations is the same for high and low oil prices. As noted, we treated carbon pricing and flexible regulations as substitutes in the 2017 to 2030 period, but increasingly as complements in the 2030 to 2050 period. While the flexible regulations undoubtedly have fairly high implicit carbon prices to 2030, the explicit carbon prices are kept low. After 2030, these prices rise more rapidly. But by this time, low- and zero-emission technologies and energy forms are well established. For many people, and the economy as a whole, high carbon prices will not have the same financial impact. Per capita carbon emissions are falling rapidly and so per capita carbon taxes would be modest and falling, even though the carbon price is rising. In terms of political acceptability, this would be less difficult than relying principally on emissions pricing from the start. Not easy, but less difficult.

Finally, as noted above, the estimation of domestic emissions reductions is significantly complicated when some provinces, or the entire country, belong to a cap-and-trade system with non-Canadian partners, as is currently the case with Quebec, Ontario and California. If well-designed, linking of cap-and-trade system can enhance efficiencies by achieving the least cost reductions over a larger area. However, if reductions in other jurisdictions would have occurred in the absence of linking cap-and-trade systems (such as reductions in California due to its domestic regulatory policies), crediting permits bought outside of Canada towards Canada's emissions targets is problematic. To avoid assessing this potential loophole, we focus in this report on emissions reductions actually occurring in Canada. We also note that even if permit purchases from other jurisdictions were counted towards Canada's target, Canada would still be a long way away from achieving its Paris target with the current and recently announced provincial and federal policies in place.

IV.2 Sectoral Results

Figure 3 shows the trajectory of sectoral emissions under the emissions pricing and flexible regulations scenarios with high oil prices. (The case of low oil prices is similar.) In the regulations scenario, more reductions occur in transportation since the regulations are designed to push for zero-emissions by mid-century. In contrast, even an extremely high carbon price will not eliminate all use of fossil fuel-derived gasoline and diesel.

Figure 3: Sectoral emissions under emissions pricing and flexible regulations scenarios

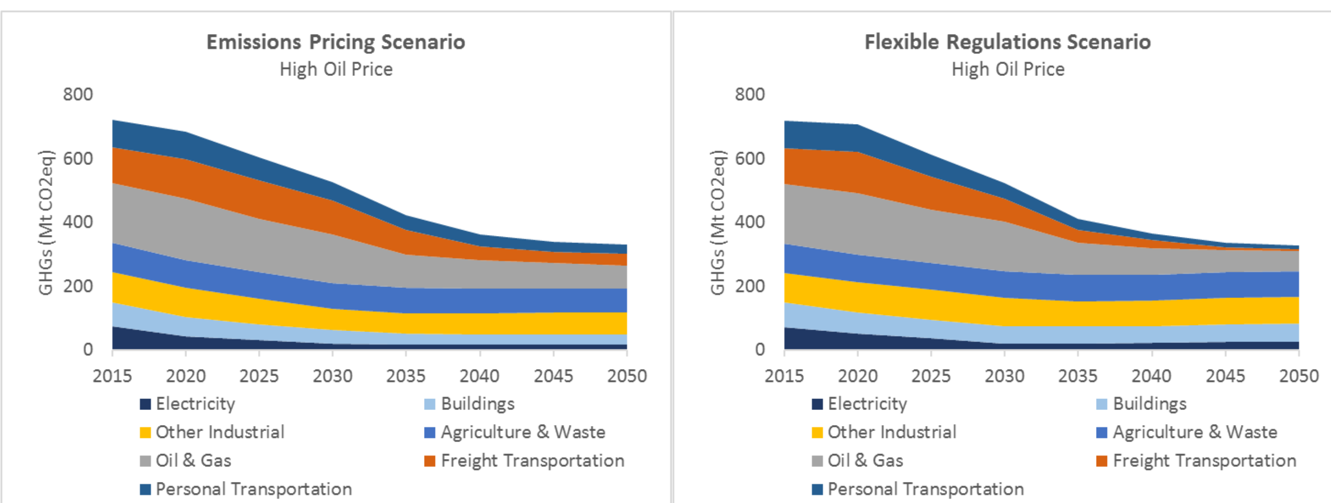
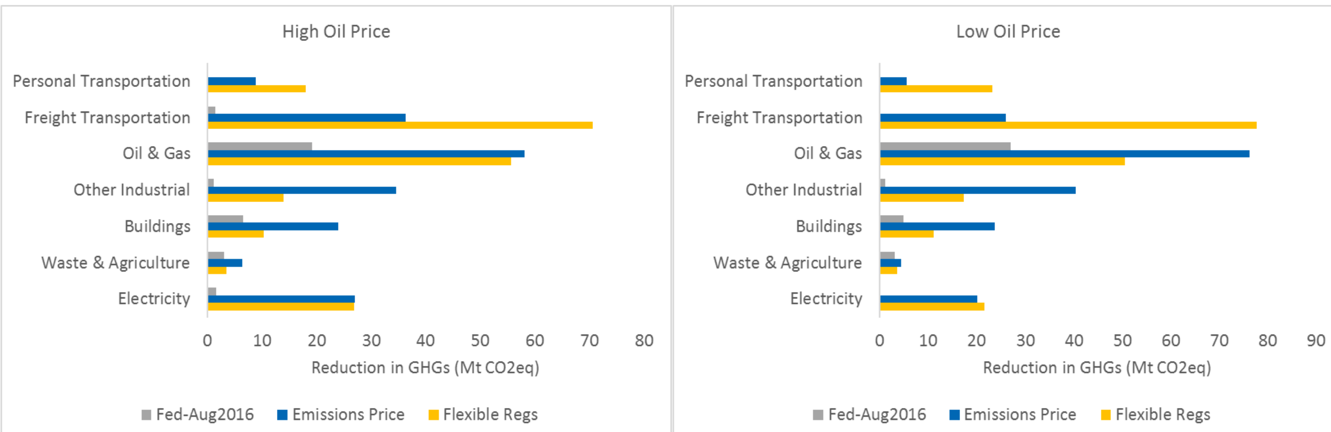


Figure 4 shows the sectoral results relative to BAU emissions in 2030. Focusing on the emissions pricing and flexible regulations scenarios, we see that emissions reductions are very similar in the electricity sector, suggesting that our regulatory policy approach imposes similar costs on that sector. By design, we see greater reductions in industry in the carbon pricing scenario, contrasted with greater reductions in transportation in the regulatory approach scenario. As explained earlier, our regulatory approach was designed to be less stringent with trade-exposed industries in order to reduce GDP and structural impacts. To compensate, since both scenarios achieve the Paris target, we require sectors with less trade-exposure, particularly transportation, to make up the difference in emissions reductions.

Figure 4: Changes in sectoral emissions in 2030 relative to BAU



The less stringent performance standards for trade-exposed industries gives a lower implicit carbon price trajectory. We estimate it, using CIMS alone, as reaching almost $100/tCO_2$ by 2030. In contrast, the more stringent performance standard for 'unprotected' industries yields an implicit carbon price closer to $200 by 2030. Again, these prices would be about 10-20% lower if CIMS were combined with a CGE macro-economic model.

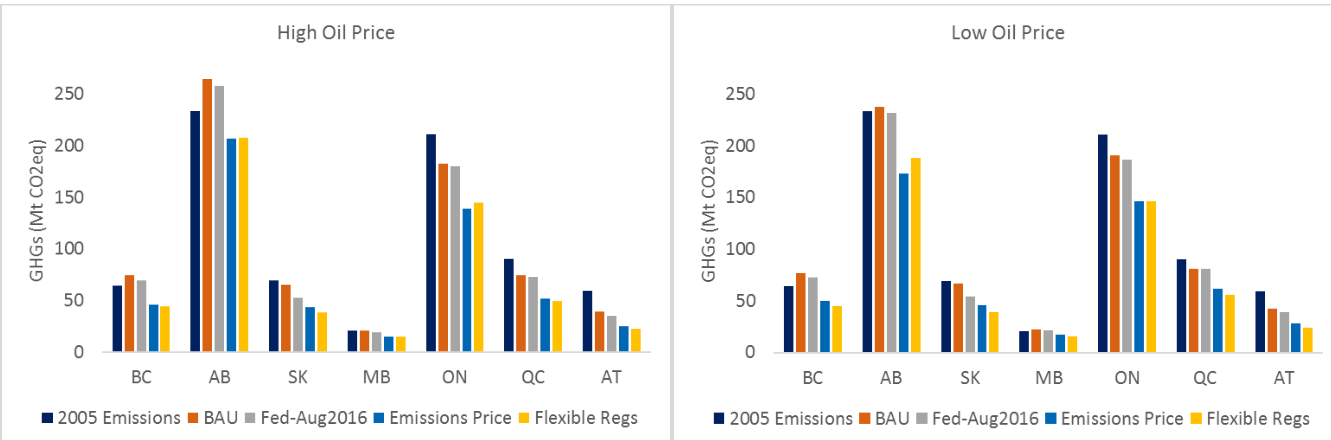
For the oil sands, the implicit carbon price of Alberta's performance standard is different in the case of high oil prices. Under high oil prices and high oil sands production, the 100 Mt emissions cap represents a severe constraint. The implicit emissions price is closer to $200 in 2030, effectively treating the oil sands like a sector that is not trade exposed.

A final point on the sectoral results is that our regulatory approach achieves fewer reductions in buildings in comparison to the carbon pricing scenario. As mentioned earlier, while we chose to focus on a smaller list of regulatory policies that target the areas with the largest emissions reduction potential, we believe that a comprehensive regulatory approach would also include policies targeted at buildings, which would reduce the difference in emissions between the carbon pricing and regulatory scenarios.

IV.3 Provincial Results

Figure 5 shows emissions by province in 2030 under all four scenarios. Since our regulatory approach applied less stringency to trade-exposed sectors, it shows higher emission in Alberta under low oil prices relative to the emissions pricing approach. Of course, an emission pricing approach can also be applied that provides favorable treatment to trade-exposed sectors under low or high oil prices. So this outcome is simply a function of our particular design of the two scenarios. Other than this discrepancy, the figure shows that the two approaches call upon similar levels of effort from the provinces in achieving the Paris commitment.

Figure 5: Provincial emissions in 2030 under each scenario



IV.4 Economy, Energy and Technology Outcomes

As noted, we can only approximately estimate GDP effects of climate policies, in this case by relying on previous applications of CIMS in conjunction with a CGE model. But given that our sectoral and provincial outcomes are not significantly different from those produced by a pure emissions pricing approach, it is unlikely that the GDP outcomes would differ greatly. Both types of policies provide financial incentives to reduce emissions. Both types of policies leave it to firms and households to decide the appropriate mix of changes to technologies, energy forms and behavior to reduce emissions in the face of increasingly stringent climate policy.

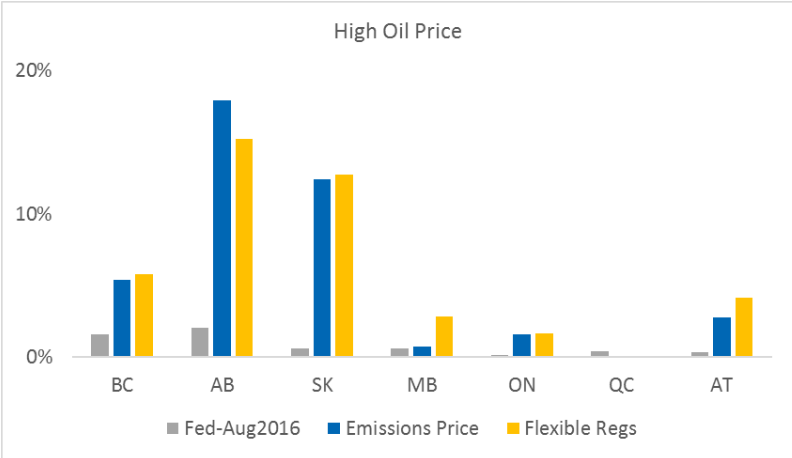
We note, however, at least two reasons why, even with these similar technological and cost outcomes, the emissions pricing approach would be more economically efficient. First, if the emissions price is pin-pointed on the emissions, it maximizes the response opportunities for firms and households. A flexible vehicle regulation allows them to pick any low-emission vehicle. But an emissions price allows them to pick any low-emission vehicle, but also to switch to transit or travel less. Are estimate, nonetheless, is that this broader option will not have a huge effect on the total costs of emissions reduction. In the case of vehicle use, for example, research shows that vehicle use is important to people even if it becomes much more expensive. Even a dramatic reduction in GHG emissions is unlikely to push more than a small percentage of people to use vehicles significantly less.

Second, if revenues from emissions pricing are used to reduce other growth-inhibiting taxes, there will be a positive effect on GDP. Studies suggest that this ‘double dividend’ from pricing emissions might compensate as much as 25% of the GDP cost. We note, however, that, with the exception of BC, governments in Canada, Scandinavia and California that have implemented some form of emissions pricing have not used the revenues in this way.

Electricity prices

Another indication of the economic implications of different policy approaches is to compare their effects on energy prices. Figure 6 shows changes in residential electricity prices in 2030 for each of the scenarios relative to BAU. We only present the case of high oil prices since its results are not dramatically different from the case of low oil prices.

Figure 6: Residential electricity price change in 2030 relative to BAU by province

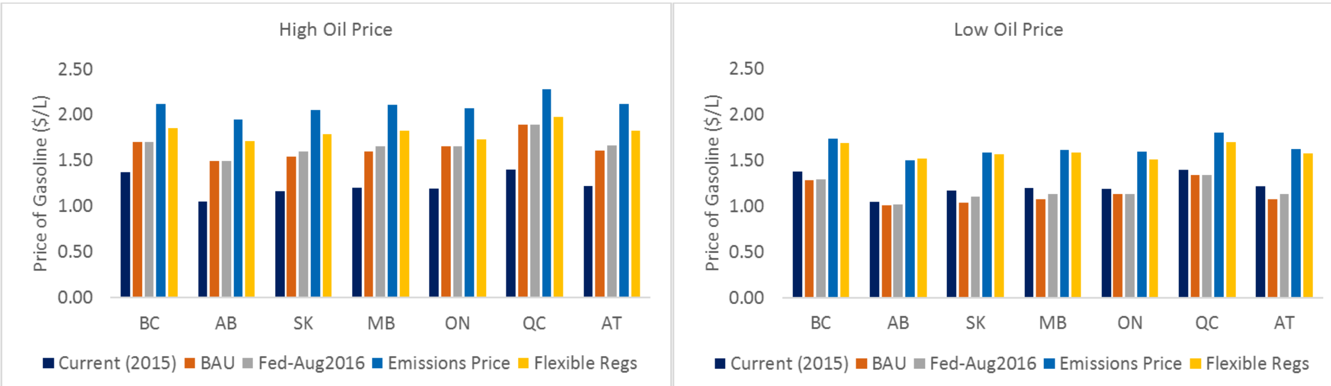


Relative to BAU in 2030, the Fed-Aug2016 scenario results in little change in electricity prices, which is expected given that it results in little change in greenhouse gas emissions relative to BAU. In the emissions pricing and flexible regulations scenarios, Alberta and Saskatchewan see the largest increases in electricity prices above BAU in 2030 because they rely the most on fossil fuel electricity generation. However, these increases are relatively small at 18% and 15%, respectively, (equivalent to 2.6 and 2.7 cents per KWh) under the two scenarios that achieve the Paris commitment, representing increases of about 1% per year in real terms. The increase in Alberta is slightly higher in the emissions pricing scenario as a result of greater emissions reductions relative to the regulatory approach. This does not indicate that the regulatory approach was somehow more economically efficient, as the outcome is the result of how the two scenarios were designed. Overall, though, cost impacts are not greatly different.

Gasoline prices

We calculated the retail price of gasoline in each province in 2030 as the average cost of gasoline and ethanol-85, with each fuel weighted by its share of sales. Retail prices include any emission prices and any retailer mark-up of gasoline in order to cross-subsidize ethanol-85 to meet sales requirements under the low carbon fuel standard and other policies. Note that the BAU scenario shows, as expected, significantly higher gasoline prices than today in the case of high oil prices. With low oil prices, gasoline prices are not much different, if anything slightly lower once accounting for the effects of inflation. Under the Fed-Aug2016 scenario, however, the price of gasoline in 2030 was almost the same as in the BAU scenario, with only a slight increase in provinces that did not have emissions pricing policies under BAU.

Figure 7: Retail price of gasoline in 2030 by province



Focusing on the case of high oil prices, the emissions pricing scenario resulted in a greater price increase than the regulatory approach – 40 cents per litre above BAU price compared to 15 cents in the case of regulations. The higher increase under the emissions pricing scenario occurs because the carbon price is being applied to all carbon emissions from gasoline, whereas in the regulations scenario the price of gasoline is only increasing to the extent needed to cross-subsidize ethanol-85 to make it competitive with gasoline and to pay for purchases of low carbon fuel credits.

Even with the dramatically higher emissions price, ethanol-85 is used to fuel only 5% of vehicles nationally in the emissions pricing scenario. In the regulatory scenario, ethanol-85 fuels 25% of vehicles. This result highlights a potential advantage of the low carbon fuel standard in that it mandates a shift towards increased low carbon fuel infrastructure that the carbon price is still not high enough to cause. On the other hand, it may also point to a deficiency of the regulatory approach. By mandating a minimum percent of low carbon fuels, the regulation cannot be met by other potentially less-expensive ways of reducing emissions that might be better spurred by carbon pricing, such as shifting to greater use of public transit and active forms of transportation.

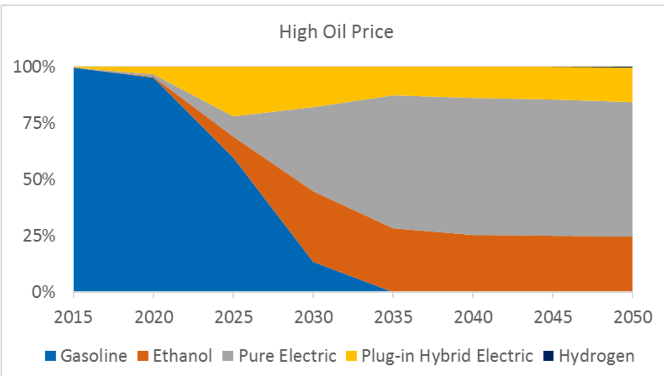
In the case of low oil prices, retail gasoline prices are much closer in the two scenarios that achieve the Paris target. The reason is that with low gasoline prices, gasoline retailers must significantly mark-up the price of gasoline in order to cause enough of a shift to ethanol-85 and perhaps electric vehicles to meet their quotas under the low carbon fuel standard.

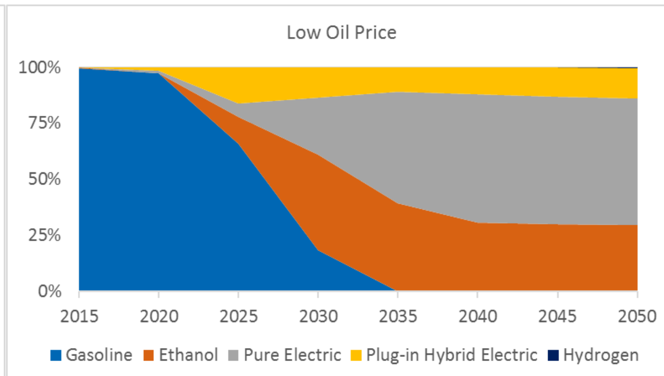
Personal vehicle shares

The combined effect of emissions pricing and regulations, weighted differently according to the scenario, drive dramatic emissions reductions in transportation to 2030 and especially afterwards. These are inevitably associated with a significant, fairly rapid shift away from gasoline and diesel use in personal vehicles and freight trucks.

Figure 8 shows the shares of new personal vehicle sales in each year under the regulatory scenario. The big transition occurs in the period 2025 to 2035, which is only possible by starting the niche market regulation before 2020. To give consumers and manufacturers time to adjust, the PZEV policy must start immediately, ramping up gradually at first and then accelerating with mass production and a widening range of vehicle options. Given the technology and consumer preference assumptions in our model, hydrogen fuel cells are not able to penetrate the market. Of course, with different assumptions, they could do very well. By 2030, pure electric and ethanol-85 vehicles dominate the market. Again, with different assumptions plug-in hybrid electric vehicles (PHEV), perhaps using ethanol, might have achieved a much larger share than simulated by the model.

Figure 8: New personal vehicle sales in the flexible regulations scenario



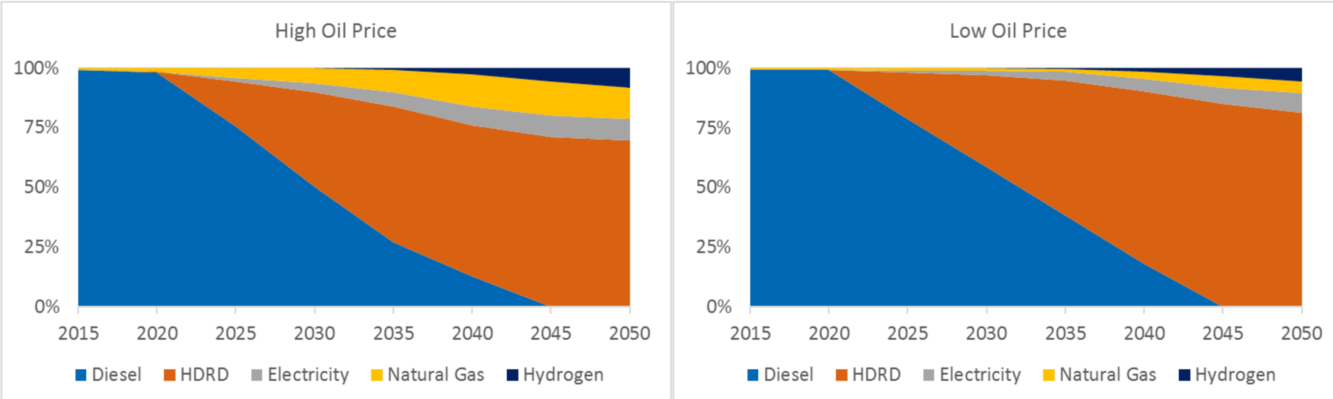


Freight truck fuel use shares

Our results for freight trucks are very different from the results for personal vehicles. Although some experts argue that electricity and perhaps hydrogen will play key roles as low- and zero-emission options come to dominate intra-urban and inter-urban trucking, the current assumptions in our model lead to an increasing use of HDRD. This fuel, made from biomass feed-stocks in low-emission processes (because of our regulations on biofuel production), can be blended with conventional diesel in any mixture. The fuel penetrates the market as the low carbon fuel standard forces diesel retailers to blend increasingly higher percentages of HDRD into conventional diesel. In the 2025 to 2035 period, the shift from conventional diesel to HDRD is quite dramatic under our flexible regulations scenario.

Figure 9 shows this evolution of fuel consumption by freight trucks. While electric, natural gas and hydrogen vehicles capture some market share, HDRD dominates under the assumptions in this version of the CIMS model. Since this fuel works with existing technologies, it is highly competitive in the transition to low-emission transportation. And we were unable to find evidence that the cost of producing HDRD would rise dramatically above current levels as more land was dedicated to this amount of biofuel production in Canada and as our regulations required low-emissions from HDRD production plants. Again, different assumptions could lead to a different outcome, but our assumptions about the cost of expanded biofuel production are consistent with much of the literature.

Figure 9: Total share of fuel use by freight trucks in the flexible regulations scenario

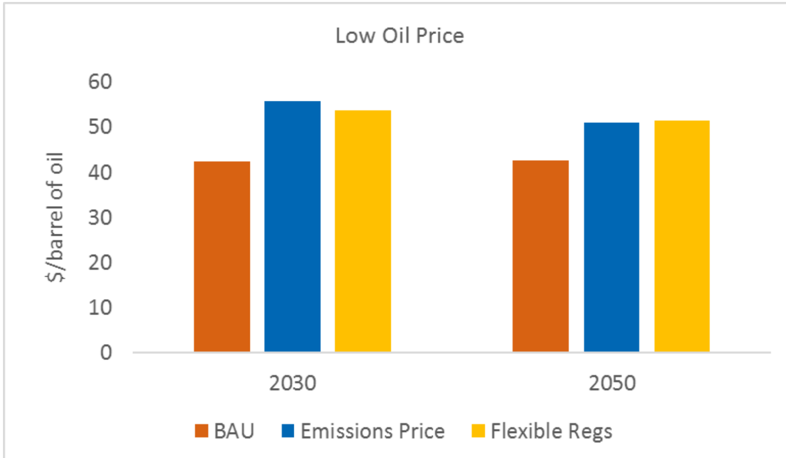


Oil sands production costs

Another important consideration is the effect of climate policy on the cost of oil sands production. By 2050, both the emissions pricing and the flexible regulations scenarios will cause significant reductions in emissions from the production of oil sands, but this increases the cost of oil sands production relative to the BAU scenario. Figure 10 shows these costs for the low oil price case in 2030 and 2050. By 2030, carbon pricing forces greater reductions than occur under our proposed regulations, which explains why production costs are higher in the carbon pricing scenario. In the regulations scenario, oil sands were simply held to Alberta's promised 100 Mt cap up to 2030, as they were in BAU. However, the cost of production of oil sands is higher under the regulations scenario in comparison to BAU because of investments made to reduce emissions in response to the moderate national emissions price of $40/tCO2 and the foresight function in our model that predicts additional investments made in anticipation of the future more stringent federal performance standards. By 2050, oil sands emissions reach the same low levels in both the carbon pricing and regulations scenarios, so the effect on the cost of production is approximately the same.

It is important to note that these production costs do not include carbon taxes or other levies. These are imposed in the model and influence the acquisition of emission control technologies, but it is assumed that all carbon tax (or allowance) revenues are recycled back to industry participants, so that the emissions pricing costs do not appreciably affect the average cost of production. Finally, it is important to note that oil sands output is fixed in our high and low oil price cases, meaning that the demand for oil sands oil is unresponsive to changes in production costs. This is unrealistic, but since we have not connected our model to a global oil supply-demand model, we externally fixed the two oil price scenarios in order to show a wide range of outcomes for this important yet highly uncertain sector in achieving a national emissions target. In the case of the low oil price, however, we note that the cost of oil sands production, under regulations and emissions pricing, is somewhat higher than the oil price. Given the long-lived capital in the oil sands, this situation could endure for some time. Oil sands operations could operate as long as their revenues covered operating costs and some of the costs of capital upkeep.

Figure 10: Oil sands production costs under emissions pricing and regulations scenarios



V. Conclusions

For almost three decades, economists have told politicians that they must price GHG emissions in order to reduce them. For almost three decades, politicians have not done so. In the few cases where they have, the emissions prices have been too low to materially reduce GHGs.

Since late 2015, the Canadian government has expressed a keen commitment to reduce GHGs, and 'must-price-emissions' advocates have intensified their efforts. Even federal politicians now say that Canada must price emissions. Notably, however, these politicians remain silent on whether Canada should rely principally on emissions pricing to achieve the 2015 commitment in Paris to reduce national emissions 30% by 2030. We believe this silence is not an accident, but instead reflects the same conditions that have produced inaction or ineffective action for three decades. The emissions price needed to significantly reduce emissions will be politically unacceptable. Our political leaders know that they cannot enact such policies and hope to get re-elected.

The analysis we summarize in this report was motivated by the apparent inability of emissions pricing advocates to incorporate key social science research explaining why there has been little or no emissions pricing while, in some jurisdictions, a few non-pricing policies have caused significant reductions. One example is Ontario's closure of its coal-fired power plants. Another is British Columbia's flexible, zero-emission electricity requirement. Yet another is California's slate of flexible regulations that are reducing emissions from electricity generation, vehicles, fuels and other sources.

We extract a few key points from this social science research:

1. 'Effective' climate policy (meaning policy that significantly reduces emissions) is inherently politically difficult.

2. Many regulatory policies, although politically difficult, appear to be less so than emissions

pricing – especially than the carbon tax approach to emissions pricing.

3. While emissions pricing can provide an additional economic benefit, if carbon tax (or allowance auction) revenues are used to reduce other growth-inhibiting taxes, experience thus far suggests that politicians are unlikely to recycle most emissions pricing revenue in this way.

4. Absent this ‘tax-shifting’ benefit, advocates argue that because of its technological neutrality, and uniform pricing treatment of all emission sources, emissions pricing significantly reduces the costs of GHG reduction relative to regulations. But these asserted benefits are theoretical, estimated by comparing pure and perfectly applied emissions pricing to especially inefficient, command-and-control regulations.

5. Flexible regulations, however, as applied by motivated jurisdictions like California, try to mimic the cost-minimizing incentives of emissions pricing. Yet emissions pricing advocates seem unwilling to estimate the extent of the economic loss that a given economy might face by taking this approach to effectively reducing emissions.

This report summarizes our attempt to address this gap in applied climate policy analysis in Canada. We present a scenario of flexible regulations applied to key Canadian emissions sources. We compare this to an emissions pricing scenario that achieves the same Paris GHG commitment for 2030. From this exercise, we draw the following preliminary conclusions:

1. To achieve the Paris commitment relying primarily on emissions pricing, Canada needs an economy-wide emissions price that starts now at $30/tCO2 and rises about $15 per year to reach $200 by 2030.

2. A set of flexible regulations could achieve a similar reduction, but with an explicit emissions price at only $40 in 2030. The implicit price of many of the regulations would, however, be in the $200 range by 2030.

3. While the government could adjust flexible regulations to approximate the effect of a single emissions price for all emissions in the economy, it could also adjust the regulations to protect trade-exposed, carbon-intensive industries in the case where countries with competing industries do not have comparable climate policies. Our flexible regulations scenario deliberately provides favorable treatment to these trade-exposed sectors. This could also be done with emissions pricing, as is currently the intent of policies being implemented in Quebec, Ontario and Alberta.

4. Flexible regulations could be used to generate very similar technological outcomes and energy service costs as emissions pricing. Nonetheless, we believe that the emissions pricing approach would be more economically efficient because it allows even more flexibility. While it appears that the cost difference would not be great, we believe that more research is needed and hope that others explore this critical question.

5. Emission pricing revenues could be used to reduce growth-inhibiting taxes, providing an additional economic benefit relative to flexible regulations. Thus far, however, only British Columbia has used some of its emissions pricing revenues in this way. So this theoretical benefit

of emissions pricing may not materialize from the politically difficult process of implementing effective climate policy.

6. Like emissions pricing, the flexible regulations approach does not need government expenditures to reduce emissions. Evidence suggests that such expenditures are usually ineffective in any case. Indeed, one could argue that a detriment to emissions pricing is that it generates revenues governments might use ineffectively. Flexible regulations avoid this temptation.

8. Some advocates argue that emissions pricing revenues could also be used to offset undesired redistributive effects of climate policy, whether for income groups or regions of the country. Again, however, the question is whether emission pricing revenues will be used this way in practice. A flexible regulation with vehicles should not have significant redistributive effects by region or income group, which is why it is best – for economic efficiency – that such a policy be implemented by the federal government rather than each province. In contrast, because the emissions intensity of electricity generation varies significantly across the country, federal regulations need to be sensitive to different costs for different regions. We designed our regulations to minimize regional effects, but as our data on electricity prices shows, this is one sector where the federal government might decide to provide modest assistance to a few provinces in the transition to near-zero-emission electricity.

9. While emissions pricing and flexible regulations might be considered substitutes in the early stage of the energy transition, the regulations create favorable conditions for a greater reliance on emissions pricing in later stages, as low- and zero-emission technologies and energy forms achieve economies of scale in production and greater consumer acceptance through the process of competition, innovation, adoption and market feedbacks. Emissions pricing is easier when consumers have desirable market options for avoiding the tax or permit allowance cost.

With their instinctive desire to succeed electorally, politicians around the world have been reluctant to rely primarily on emissions pricing. This is unlikely to change. Fortunately, they have policy alternatives that can be effective and are likely to be less politically difficult. Such policies have already been implemented with success in a few jurisdictions.

These policies will also be less economically efficient. But if the efficiency cost is modest, it may well be worth it if the costs of continued ineffective policy are considered. Thus far, few researchers have explored this critical question. By presenting our preliminary findings in this report, we hope to motivate others to research win-win options for accelerating the energy transition that is needed to avoid the looming costs of climate change.