PMR | PARTNERSHIP FOR MARKET READINESS

Discussion Paper

The role of a carbon price in tackling road transport emissions

WORLD BANK GROUP

Design: *simpelplus*

Acknowledgments

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Contents

List of Boxes, Tables and Figures

List of Acronyms

CO_2	Carbon dioxide
EU	European Union
ETS	Emissions trading system
EV	Electric vehicle
GDP	Gross Domestic Product
GHG	Greenhouse gas
HOV	High-occupancy vehicle
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
NDC	Nationally determined contribution
OECD	Organisation for Economic Co-operation and Development
PAYD	Pay as you drive
PMR	Partnership for Market Readiness
RD&D	Research, development and demonstration
SLoCaT	Partnership on Sustainable, Low Carbon Transport
tCO_2e	Metric tons of carbon dioxide equivalent
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Key points

- Road transport represents a significant and growing share of global greenhouse gas emissions. The growth is largely driven by a rapid uptake of private vehicle ownership and use in developing countries.
- The sector has opportunities for mitigation through activity reduction, modal shift, improved vehicle efficiency and lower carbon fuels (e.g., renewable electricity and hydrogen).
- Zero emission road transportation technologies have potential for large scale deployment in the coming decades. Carbon pricing can help ensure climate externalities are adequately priced, which will help the uptake of zero emission technologies. However, carbon pricing cannot address other market failures, including imperfect information and knowledge "spillovers".
- In addition, carbon pricing faces challenges in gaining public acceptance. This is particularly problematic for road transport, which is, in many countries, already heavily taxed. Carbon pricing may also disproportionately affect low-income household and impact on business competitiveness. These potential impacts need to be addressed.
- As with other sectors, road transport needs a comprehensive policy suite to ensure mitigation opportunities are realized.
- However, the role of carbon pricing in the road transport sector is not as clear as for other sectors (e.g., power), where it is often used as the central mitigation mechanism. In the road transport sector, non-pricing policies can be better placed to incentivize specific actors. For example, vehicle efficiency standards, which provide a more direct signal for manufactures to innovate, or fuel standards to promote development and uptake of low carbon or renewable fuels.
- While carbon pricing may not necessarily be the central mitigation mechanism for the road transport sector, it does have a role to play. It can:
  - address imperfections in other policies (e.g., rebound effect in vehicle efficiency standards);
  - decarbonize supporting sectors (e.g., electricity); and
  - promote equity across sectors allowing the market to determine if/when road transport can offer least cost abatement.
- In addition, carbon pricing has the potential to generate revenue, which will be particularly advantageous as the world recovers from the COVID-19 crisis. Further, unlike direct taxes, a carbon price can be placed "upstream" on fuel producers or importers, which allows for a broad coverage of transport activities. This can reduce administrative costs, promote compliance and reduce tax evasion.
- With the above in mind, it is worth further investigating (among other things): how carbon pricing can best complement other road transport sector policies; how best to design carbon pricing in road transportation to promote public acceptance; and how to promote fuel tax reform to help ensure the relative price of fuels accurately reflects their environmental and social damages.

1 Introduction

This research paper is part of the work of the Partnership for Market Readiness' (PMR) technical work program, which supports developing countries in designing and implementing carbon pricing policies. For many of these countries, the transport sector is a significant and growing share of national emissions that will need to be tackled in order to reach the temperature goals of the Paris Agreement. Almost three quarters of global transport emissions come from road vehicles and they are largely responsible for the rise in transport emissions (IPCC, 2014). Rising GDP, car ownership and e-commerce will all place increasing mobility demands on developing countries. If left unaddressed, this would lead to a continued rapid rise in road transport sector emissions. As such, this paper looks at the potential role explicit carbon pricing[1] could play in decarbonizing the road transport sector, the benefits, challenges and barriers of carbon pricing, and potential areas for future work.

The road transport sector includes multiple modes of transport, which can be broadly categorized as either passenger (e.g., light-duty vehicles, such as motorcycles, cars and vans) or non-passenger (primarily medium/heavy-duty vehicles, such as long-haul trucks). This paper focuses on passenger vehicles, noting they represent the largest component of the road transport sector. The mitigation opportunities and policy challenges are conceptually similar for non-passenger transport (i.e., freight). However, non-passenger transport has additional complexity because of the wider range of vehicle types, with different load and usage profiles.[2] Accordingly non-passenger policy development requires additional consideration of the mode-specific characteristics (e.g., key actors and segments travelled etc.), to ensure policies are fit-for-purpose.

The paper is structured into five sections. Section 2 introduces the emissions profile for the road transport sector and the four main abatement opportunities: (i) activity reduction; (ii) modal choice and supporting infrastructure; (iii) energy intensity (e.g., vehicle efficiency); and (iv) fuel carbon intensity. Section 3 discusses the benefits and challenges of implementing a carbon price in the road transport sector—it is a cost-effective policy for reducing emissions, but effective implementation is limited by a range of factors including limited political acceptance and non-price related barriers. Section 4 outlines the potential for carbon pricing to play a complementary role alongside other policies. It can address key market failures, decarbonize supporting sectors, promote effort sharing across sectors and raise revenue. Finally, section 5 concludes and poses additional areas of research to promote the effectiveness of carbon pricing in the road transport sector.

1 This paper is focused on explicit carbon pricing policy enacted by a government mandate (i.e., via a carbon tax or an emissions trading system). Implicit carbon pricing and the application of an internal or "shadow" carbon price are not explicitly covered in this paper. This paper also does not discuss the impacts of fossil fuel subsidies, which create an implicit negative carbon price, as they reduce the cost of fossil fuel consumption or production (depending on the nature of the subsidy).

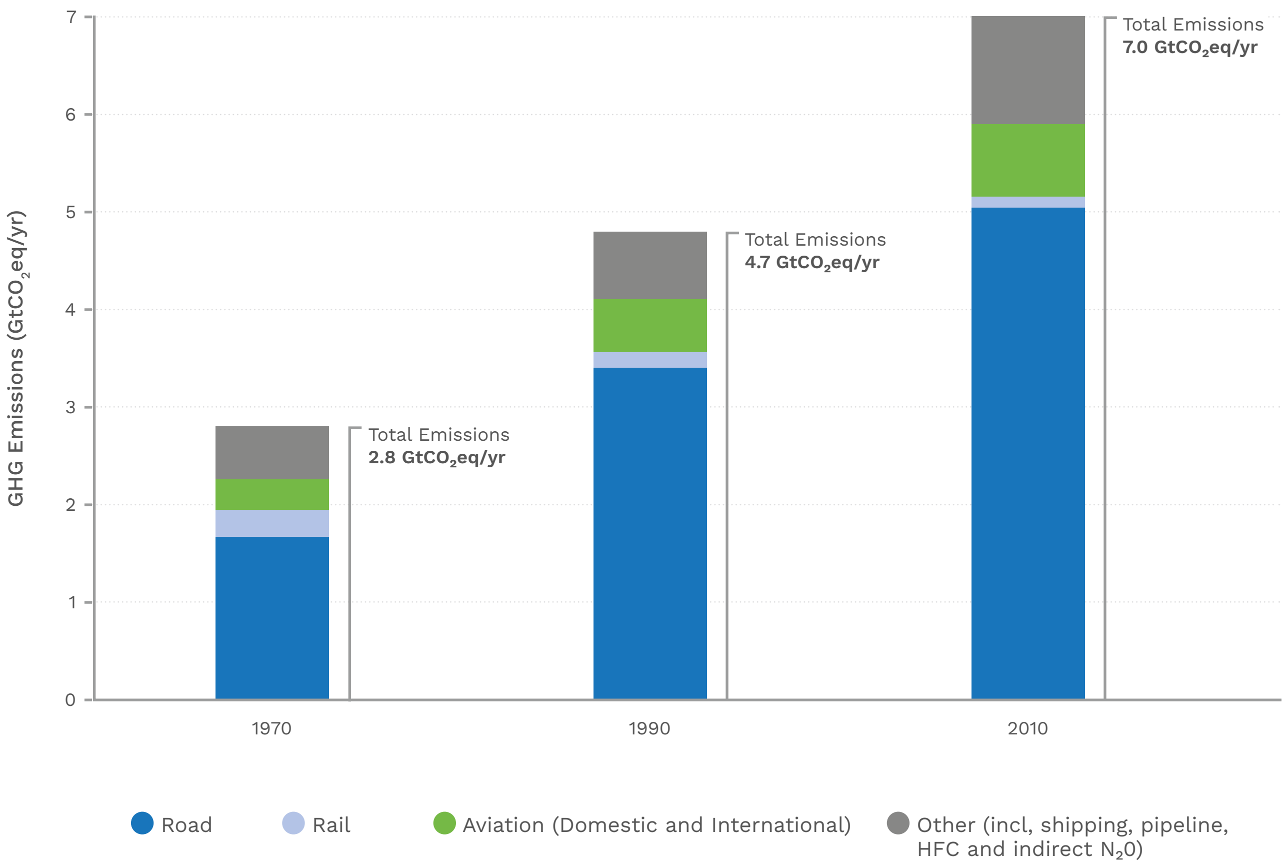
2 Axsen, J., Plötz, P. and Wolinetz, M. 2020. "Crafting strong, integrated policy mixes for deep CO_2 mitigation in road transport". Nature Climate Change. pp.1-10.

2 Road transport sector

2.1 Emissions profile

Globally, the transport sector accounts for almost a quarter of global CO_2 emissions, with road transport accounting for around three quarters of total transport emissions (IPCC, 2014). As illustrated in Figure 1, road transport sector emissions accounted for 80 percent of the rise in the sector's emissions from 1970–2010 (Wang and Ge, 2019).

Figure 1
Direct GHG emissions from the transport sector.

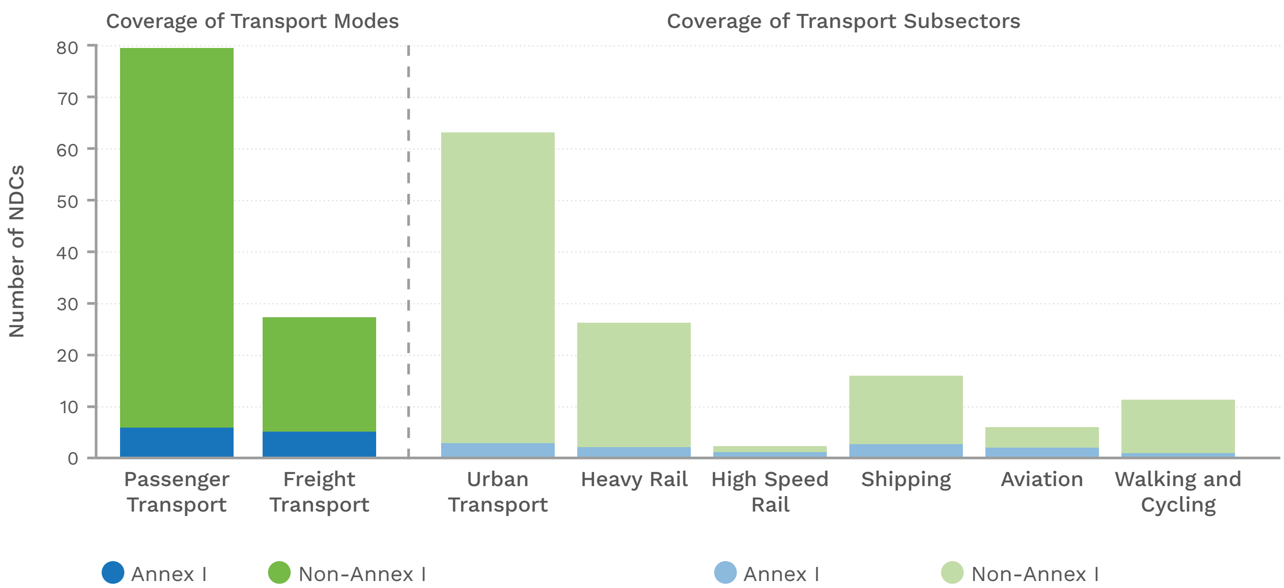


Source: IPCC, 2014
Note: Indirect emissions from electricity generation and production of fuels, vehicle manufacturing, infrastructure construction etc. are not included.

Despite improvements in energy efficiency and electrification (see section 2.2), economic growth, an increasing population and an increased demand for personal mobility mean that road transport emissions will continue to increase. Without policy interventions, the continuation of this trend could lead to transport CO_2 emissions doubling by 2050 (IPCC, 2014). While the majority of road transport emissions come from developed countries, two-thirds of transport emissions growth in the coming decades is expected to come from developing countries (IPCC, 2014). The scale of the problem posed by growing transport emissions highlights the need for greater emphasis in countries' international commitments, particularly Nationally Determined Contributions (NDCs) under the Paris Agreement. Of the originally submitted 166 NDCs, 76 percent highlight the transport sector as a mitigation source, with coverage tending to focus on passenger and urban transport (Figure 2). However, only 8 percent of NDCs include explicit transport emissions reduction targets '(SLOCAT, 2018).

Figure 2

Transport modes and subsectors in NDCs; SLOCAT 2018.



Despite this, there are other positive signs of mitigation action in the transport sector, particularly through increased momentum to decarbonize vehicles, with pledges from national governments (e.g., China, India, and France); sub-national governments (e.g., California, City of Oslo, and City of London); and car manufactures (e.g., Volvo, Volkswagen and General Motors) to phase out combustion engine vehicles (or promote zero-emissions vehicles) over the period to 2050.[3]

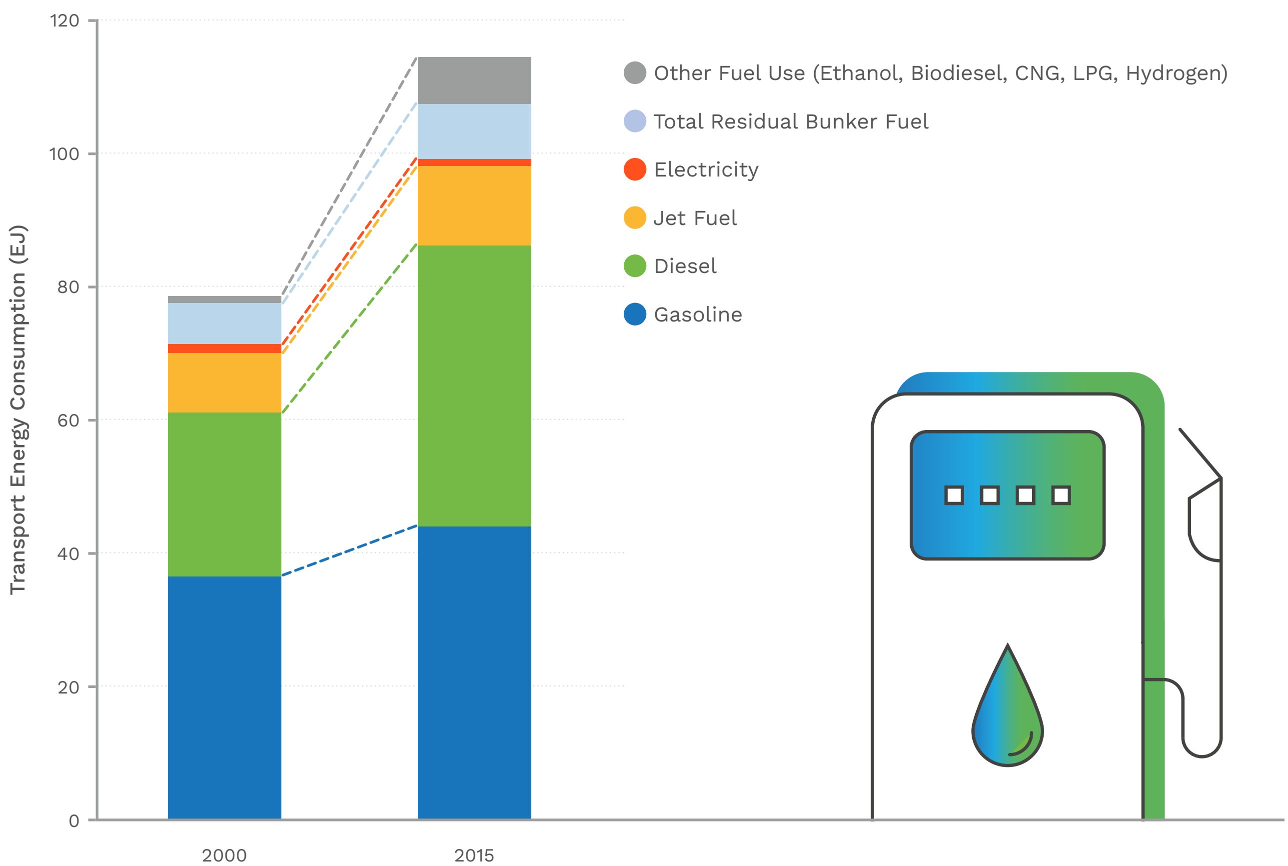
3 *International Energy Agency. 2020. Global EV Outlook 2020. Technology report — June 2020.*

2.2 Energy consumption

Transport sector energy consumption increased around 44 percent from 2000 to 2015, while total emissions increased 31 percent, reflecting some improvements to carbon intensity. However, these improvements are insufficient to decarbonize the sector (IPCC, 2014). The IEA (2020) estimates that transport sector energy intensity would need to fall 3.2 percent on average annually, which is more than twice the rate of decrease from 2000-2018. Breaking down energy use by fuel source indicates a continued reliance on oil, with road transport accounting for half of all global oil consumption in 2015. Electricity use has only improved marginally, from 0.07 to 1 percent from 2000-2015 (see figure 1 below).

Figure 3

Total transport energy consumption by fuel sources (2000 and 2015); SLoCaT 2018.



2.3 Abatement opportunities

Decarbonizing the road transport sector requires restructuring the way we move. It is a sector that is inherently more difficult to abate than other sectors (such as electricity). This is driven by a range of factors, including the diffuse and decentralized nature of emissions, low fleet turnover rates, the large influence of human behavior on consumption and activity choices, and the historical focus of innovation being on consumer convenience, rather than decarbonization.

Based on the IPCC Climate Change and Mitigation Report,[4] decarbonization requires transformation in four areas[5]:

Activity reduction. Reduction of transport activity by avoiding unnecessary journeys where possible and by reducing travel distance through improved urban planning. This can also include, for example, broader consumer decisions such as relocating to reduce commuting distance.

Modal choice and supporting infrastructure. Modal shift is aimed at shifting travel to lower carbon transport systems, such as public transport, walking and cycling infrastructure investment. This category also includes supporting infrastructure, such as improving access to low-carbon public transport options such as electric buses and trains and promoting other mobility services such as bicycle and electric scooter sharing.

Energy intensity. This includes lowering the energy intensity by improving the vehicle and engine performance, increasing vehicle load factors and passenger occupancy rates, having better-managed transport networks, and reducing the weight of the materials. This category also includes improving the efficiency of internal combustion engines and increasing deployment of new technologies, such as electric and hybrid vehicles.

Fuel carbon intensity. Reducing the carbon intensity of fuels (CO_2 per unit of energy) by substituting oil-based fuels with lower carbon (or biogenic) alternatives, such as natural gas, biofuels, electricity (see Box 1), bio-methane, or non-fossil-based hydrogen.

Box 1

Electrification

Assuming decarbonization of the power grid, vehicle electrification can play a significant role in lowering road transport emissions. In the 2019 Emissions Gap Report, the United Nations Environment Programme (UNEP) estimates just over 6 $GtCO_2e$ could be reduced annually as a result of electrifying the transport sector. The scale of this transformation is not insignificant. The International Renewable Energy Agency (IRENA) estimates the share of electricity in the transport sector would need to increase to 40 percent by 2050, as compared to just over one percent in 2019 (IRENA, 2019). Electrification requires increased uptake of electric vehicles, which currently only make up just over two percent of global market share (UNEP, 2019). The infrastructure requirements (e.g. charging stations) to support a large electric passenger vehicle fleet also presents challenges.

4 *IPCC, 2014. Transport. In Climate Change 2014 Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*

5 *Note other analyses, such as Axsen et al (2020) use similar a classification, although modal choice and activity reduction are combined into a single category "vehicle travel demand".*

2.4 Existing policies

The road transport policy space is crowded. National and sub-national governments (see Box 2) have implemented policies in the sector aimed at achieving a range of policy objectives, often simultaneously, including lowering travel costs, improving mobility, improving air quality and health, enhancing energy security, improving safety, and providing time savings (IPCC, 2014). Taxes and fees are commonly used policies in road transport, particularly in pricing fuels, but these are often aimed at achieving non-climate related objectives, such as raising revenue (see section 3.2). Climate-specific policies have tended to be non-pricing based and include a range of regulatory and other measures, such as vehicle efficiency standards, low carbon fuel standards, and grants to promote research, development and demonstration of emerging technologies (see section 4.1).

Box 2

The role of sub-national governments

Sub-national governments have an important role to help decarbonize road transport. Sub-national governments are often responsible for community governance and/or regulatory enforcement (e.g., parking fines), own and/or operate local infrastructure, and implement local education and outreach programs. Further, sub-national governments are also often responsible for urban planning and promoting access to (and often operating) public transport systems. For these reasons, it is essential that sub-national governments are appropriately resourced to plan and implement climate mitigation (and adaptation) policies in a proactive and coordinated way. National governments should work with sub-national jurisdictions to promote policy coordination and a cohesive response to climate change.

3 Carbon pricing in road transport

A carbon price can provide economic incentives for producers (e.g., car manufacturers) and consumers to adopt mitigation measures.[3] Its power is in its ability to change the behavior of consumers, businesses, and investors while encouraging technological innovation and generating revenues that can be put to productive use. However, there are a number of challenges to promoting innovation and encouraging behavioral changes in road transportation, as outlined in section 3.2.

Carbon pricing is generally implemented through an Emissions Trading System (ETS) or a tax (see Box 3). While a cost-effective tool in internalizing the cost of greenhouse gas (GHG) emissions, it is generally recognized that a carbon price cannot decarbonize economies on its own—there needs to be a broader suite of policies that work together to address the full range of barriers to emissions mitigation. This section describes the benefits and challenges for a carbon price in the road transport sector.

Box 3

Implementing a carbon price

There are two main ways in which a carbon price can be implemented: a carbon tax or an ETS. A carbon price could also be imposed through a domestic crediting mechanism, but this presents its own substantial challenges, largely because of the difficulties in establishing whether the emissions reduction project is additional to business-as-usual (known as "additionality"), as outlined in Appendix A. This paper does not examine the relative merits or drawbacks of an ETS or a tax. Both are effective tools to achieve mitigation outcomes at least cost and the preferred option is largely dependent on political preferences and the characteristics in the implementing jurisdiction.

Given the large number of end users in the road transport sector (e.g., potentially millions of residential consumers), an ETS will likely need to be applied upstream at the point where fuel is first commercialized by extractors, refiners, or importers. Placing the point of regulation upstream, where there are potentially fewer than a dozen liable entities, can reduce administrative costs and can enable higher coverage across the economy. This "upstream" approach has been adopted in the California Cap-and-Trade Program, where the point of regulation for transportation fuels is where they enter commerce (in practice this at terminal racks and large refineries where fuels are physically transferred). Importantly, in competitive markets, consumers face the same price signal, regardless of whether the point of regulation is upstream or at the source of emissions.

A tax could be applied upstream in the same way, such as through an existing fuel excise system. Using the existing excise system presents advantages for those countries that do not want to start from scratch and highlights a useful implementation mechanism that has been used by a number of countries to introduce a carbon price on road transport. For example, Mexico and many EU countries implement carbon taxes on transport fuels in this way. Ultimately, the type of instrument used, and the associated implementation approach, is less important than ensuring GHG emissions are priced.

3.1 Benefits

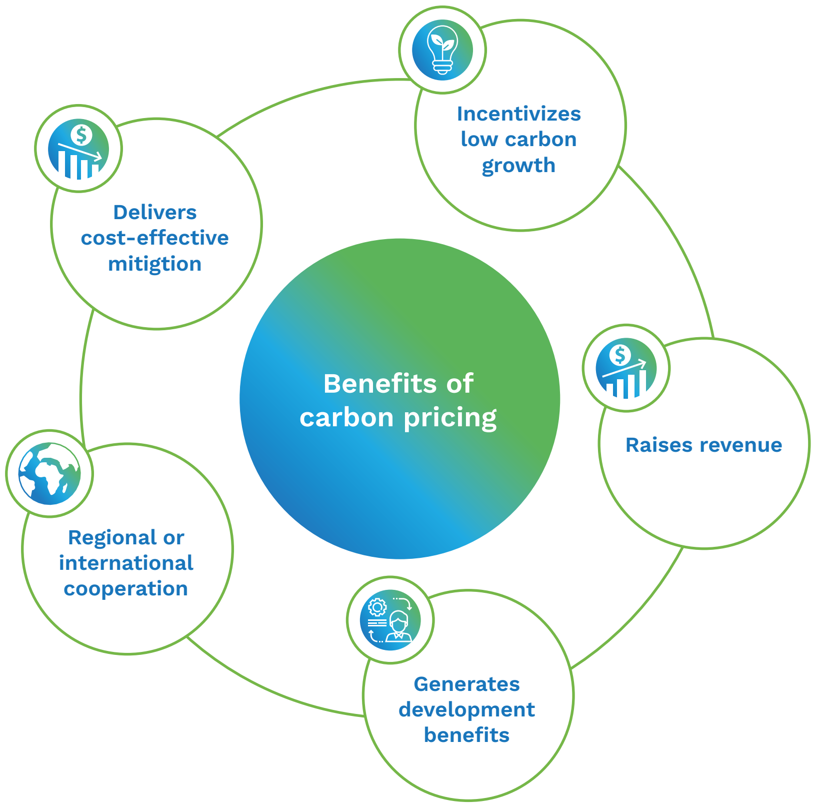
One of the most fundamental challenges to reducing GHG emissions is the failure of markets to include the cost of climate change. If firms do not face the societal costs of emitting GHGs, there is limited incentive for them to invest in reducing emissions. This market failure can be addressed by placing a price on carbon. Theoretically, introducing a carbon price in the transport sector would provide a price signal for consumers to drive less and to choose lower-emission transport options (e.g., efficient vehicles, using public transport, low carbon fuels etc). It also provides a technology-neutral incentive for vehicle manufacturers to develop more efficient vehicles, because (all other things being equal) it will result in a relative increase in demand for more efficient vehicles.

Environmental taxes (such as a carbon price) can be an efficient means for governments to raise revenue. They can have a lower marginal cost of public funds than direct taxes (e.g., on labor and capital) because they have a less distortionary effect on the economy, for example, through broadening the tax base and minimizing or avoiding distortions resulting from higher tax rates on labor and capital.[6,7] In addition, carbon pricing can be placed on a few large upstream points of regulation, which covers all downstream uses, including the informal sector (which represents 70 percent of all employment in developing and emerging economies[8]).[9] This can make a carbon price more difficult to evade than direct taxes[10], increasing coverage and compliance.[11] In 2020, approximately USD 53 billion was raised from carbon prices around the world.[12] Carbon pricing as a potential source of revenue is particularly important in the current context as it can contribute to the sustainable macro-fiscal frameworks needed for funding social assistance and post-COVID-19 crisis recovery programs.[13] The World Bank's Report on *Using Carbon Revenues* outlines several options for carbon pricing revenue use, which include assisting households and business transition, financing emissions reduction measures, and financing infrastructure investments.[14]

6 Barrios, S., Pycroft, J., and Saveyn, B. 2013. "The marginal cost of public funds in the EU the case of labour versus green taxes". European Commission Taxation Paper. Working Paper N35 – 2013.
7 Barrios, S., Fatica, S., Martinez, D., and Mourre, G. 2014. "The fiscal impact of work-related tax expenditures in Europe", European Commission Economic Papers 545. February 2015. European Commission Directorate General for Economic and Financial Affairs, Brussels.
8 OECD/ILO, 2019.
9 This is quite different from direct taxes (which tend to be the default revenue source in many countries) which need to be collected from a vast number of individuals and struggle in covering the informal sector of economies.
10 Direct taxes are where individuals make tax payments directly to the government, such as income tax,
11 OECD, 2021.
12 World Bank, 2021
13 See for Burke, J., Fankhauser, S., and Bowen A. 2020. Pricing carbon during the economic recovery from the COVID-19 pandemic. Policy Brief May 2020. London School of Economics
14 World Bank, 2019.

Figure 4

Key benefits of carbon pricing.



Source: PMR (2021) Carbon Pricing Assessment and Decision-Making: A Guide to Adopting a Carbon Price

Carbon pricing can also deliver broader economic, social and environmental benefits in addition to cost-effective GHG emissions mitigation (see Figure 4). In fact, these broader benefits are sometimes prioritized ahead of GHG mitigation.[15] Importantly, by incentivizing energy productivity (i.e., improved efficiency and/or reduced consumption), carbon pricing can promote long-term energy security by reducing the reliance on foreign-sourced transport fuels. Promoting energy security also delivers economic benefits through reduced exposure to fluctuations in global fuel market prices and an ability to capture a greater share of economic rents through increasing the domestic production of alternative fuels (e.g., biofuels or renewable electricity). Further, by incentivizing a reduction in vehicle miles travelled, carbon pricing can reduce local air pollution, traffic accidents, and congestion. Importantly, a reduction in local air pollution can provide both health benefits (such as reduced premature mortality from improved air quality), and economic benefits (such as through avoided health costs from pollution). These development benefits are particularly attractive for developing countries.

15 *See for instance Heine, D. and Black, S. 2018. "Benefits beyond climate Environmental Tax Reform" in Pigato, M. (ed). Fiscal policies for development and Climate Action, World Bank, Washington DC.*

3.2 Challenges and barriers

The road transport sector is characterized by high investment costs for low-carbon transport systems, a slow turnover of vehicles and infrastructure, and end users that are influenced by a range of non-price factors. These characteristics presents three major challenges to putting a price on carbon.

1. **Relatively inelastic demand:** Increasing fuel prices tends to have limited impact on consumers' decisions.[16] Influencing consumer behaviour through fuel prices alone is difficult for a range of reasons, including a tendency for consumers to over-discount future fuel savings,[17] and the fact that consumer decisions are influenced by a range of non-price factors (e.g., perceived social status or societal norms). However, consumers tend to be more responsive to price changes over the longer term. For example, Goodwin et al (2004) estimate that a 10 percent increase in fuel prices reduces fuel consumption by 2.5 percent within a year, but by 6 percent in the longer term.[18] Part of the reason for this could be due to consumers having greater flexibility in transport choices over the longer term, such as decisions on vehicle purchases, where they live or work, and the availability of public transport options.

   Studies specifically relating to carbon pricing suggest a more promising consumer response. For example, Murray and Rivers (2015) provide a summary of empirical and modelled analysis of the effect of British Columbia's carbon tax on fuel consumption. The reviewed studies suggested that a $30 per metric ton CO_2 carbon price caused a reduction in per capita gasoline sales in British Colombia in the order of 7 to 19 percent.[19] A carbon price's influence on manufacturers' investments also faces challenges. Raising the price of fuel provides an incentive (over the longer term) for vehicle manufacturers to innovate (e.g., through increase demand for more fuel-efficient vehicles or production of low-carbon fuels). However, there are other barriers (e.g., "knowledge spillover" effects, discussed below) that limit investment in innovation and other policies may be better placed to target vehicle manufacturers.

2. **Public and political resistance:** Carbon pricing has had a historical challenge of gaining public and political acceptance. Put simply—consumers do not like taxes. This issue is exacerbated in the road transport sector, which tends to be taxed at far higher rates than other sectors.[20] This is primarily in the form of fuel excise but also can include road tolls, registration fees and vehicle taxes (noting all of these taxes are often primarily aimed at achieving non-climate objectives, such as revenue raising or congestion reduction). Therefore, a carbon price would be imposed on an already high level of existing taxation. This, coupled with a strong reliance on transport for individual wellbeing, means that consumers (and as a consequence, governments) are reluctant to support fuel tax increases. Consumers tend to be less opposed to standards because they do not transfer a large amount of revenue to the government.[21]

   Carbon pricing also raises concerns around impacts on low-income households and trade-exposed businesses (see Box 4). However, some price increase concerns can be addressed through design and implementation options. For example, a relatively simple approach would be to recalibrate the fuel excise rates to reflect each fuel's relative environmental and social impact, without a significant net change in the fuel price. This could correct existing rates that are largely an artefact of history and primarily designed for generating revenue. For example,

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16 *Dand for transport fuel is considered to be relatively inelastic.*
17 *Greene, D.L., Evans, D.H., and Hiestand, J. 2013. "Survey evidence on the willingness of U.S. consumers to pay for automotive fuel economy". Energy Policy. vol. 61. issue C.p. 1539–1550.*
18 *Goodwin, P. Dargay, J. and Hanly, M. 2004. "Elasticities of road traffic and fuel consumption with respect to price and income a review", Transport Reviews, 24 (3). pp. 275–292.*
19 *Murray, B.C., and Rivers, N., 2015. British Columbia's Revenue-Neutral Carbon Tax A Review of the Latest "Grand Experiment" in Environmental Policy. Nicholas Institute Working Paper, May 2015.*
20 *OECD, 2019. Taxing Energy Use 2019 Using Taxes for Climate Action, OECD Publishing, Paris.*
21 *Anderson, S., Parry, I., Sallee, J., and Fischer, C. 2011. "Automobile Fuel Economy Standards Impacts, Efficiency and Alternatives". Review of Environmental Economics and Policy. Vol. 5. issue 1 pp. 89-108.*

Argentina revised their fuel tax system to ensure fuel prices reflected the relative carbon content of fuels. This meant that higher carbon fuels were taxed at a higher rate than low carbon fuels. The changes were implemented using the existing fuel tax framework in a revenue-neutral way to change relative fuel prices but maintain government revenue.[22]

Box 4

Impacts on households and businesses

Two common concerns raised in relation to carbon pricing are the potential impact on households, particularly poorer households, and on business competitiveness. By increasing the price of fuels, carbon pricing has the potential to disproportionately affect low-income households, where those households spend a high proportion of income on fuels, are reliant on carbon-intensive fuels and/or have limited access to cost-effective alternatives (e.g., newer, more efficient vehicles). In addition, carbon pricing presents a risk that domestic fuel prices are higher than neighboring jurisdictions, which presents a risk of "carbon leakage".[22] This could be an issue for multi-jurisdictional freight carriers, who could shift fuel purchases (at the margin) to jurisdictions not subjected to a carbon price. The potential impacts on households and businesses are important considerations for policymakers, noting that the policy design can be adjusted, including how revenue is used, to minimize any potential negative impacts.

3. **Limited effect on non-price barriers:** A carbon price focuses solely on the failure of markets to price GHG emissions. While important, as highlighted in the High-Level Commission report on Carbon Prices[24], there are other failures in the road transport sector that are not addressed by carbon pricing, including:

- **Imperfect information:** Information about vehicle efficiency or the carbon content of fuel is not always readily available, making it difficult for consumers to make informed decisions. Further, understanding the longer-term benefits of higher efficiency can be complex and consumers tend not to undertake the analysis necessary and/or undervalue long-term benefits against short-term costs. This can result in underinvestment in efficient and low/zero-emission vehicles.

- **Knowledge "spillovers":** Like many other sectors, technological innovation and commercial uptake are critical to decarbonizing the transport sector. However, there are a number of market failures primarily related to "spillover" effects, which is where the private sector underinvests in the research, development and demonstration (RD&D) activities that are essential to fostering innovation and technological diffusion.[23] When a private firm invests in RD&D they create knowledge that can be shared by (or "spilled over" to) others. In this way, private companies that invest in RD&D suffer the costs but are unable to capture all the benefits, leading to underinvestment. While some frameworks and tools exist to protect some types of RD&D investment, such as patents, spillover risks still exist.

22 OECD, 2019. Taxing Energy Use 2019 Using Taxes for Climate Action, OECD Publishing, Paris.
23 Carbon leakage occurs when activity moves from a jurisdiction with a carbon price to another jurisdiction that without a carbon price or with a lower carbon price. The risk is slightly different for transport activities, which are geographically fluid. Carbon leakage risks present a combination of undesirable environmental, economic, and political outcomes. However, there is little empirical evidence of carbon leakage to date.
24 High-Level Commission on Carbon Prices. 2017. Report of the High-Level Commission on Carbon Prices, Washington, DC, World Bank

- **Network effects, coordination failures and imperfect markets:** The integrated nature of transportation systems makes it difficult for markets to incentivize the necessary infrastructure investments, due to high upfront costs, perceived (or real) risky long-term returns and coordination requirements between jurisdictions and governments. Importantly, transport infrastructure investments (e.g., EV charging or electric trains) require a threshold of users to make it financially attractive. This makes it difficult for private sector investors to make the necessary financial commitments. Finally, underinvestment in "green" infrastructure is also a result of incomplete and imperfect capital markets resulting from relatively illiquid assets, real or perceived uncertainty and riskiness, and long payback periods.[23]

These failures require other policy tools that are discussed in section 4.

4 Carbon pricing as a complementary policy

4.1 Road transport mitigation policies

Carbon pricing is just one tool within a wider policy toolbox and should form part of a broader suite of mitigation policies. For many jurisdictions, carbon pricing is central to decarbonization, particularly in the industrial and power sectors. However, the role of carbon pricing in the road transport sector is not as clear. This is largely due to the characteristics of the transport sector, including individuals generally undervaluing fuel economy benefits; the large impact of behavioral and cultural influences; the need for public infrastructure and investment with high investment costs, long payback periods and relatively high risk; and the complexity of the new vehicle market which, among other things, creates a barrier to new entrants.

With this in mind, alternatives to carbon pricing can be better tailored to address specific environmental or social externalities.[25] For example, vehicle efficiency standards provide a direct obligation on manufacturers to innovate, which is not affected by fuel price volatility and the presence of innovation "spillovers".[26] Similarly, public investments in infrastructure (e.g., charging stations, expanded public transit networks) can be more effective at encouraging low-carbon transit options than a carbon price (while also improving accessibility).

While a number of jurisdictions (including California, Québec, New Zealand, and – from 2021 – Germany) are using carbon pricing as a central policy to reducing transport emissions, other policy mechanisms have historically been more commonly used as the primary driver to promote abatement opportunities in the road transport sector. Table 1 summaries the available policy options and provides an indication of how each identified option promotes action across the four abatement categories identified in section 2.3. Table 1 is not intended to be exhaustive and oversimplifies the extent to which each policy promotes action. Rather, it is intended to illustrate that different policies will promote mitigation across categories differently. The impact of specific policies will, of course, depend on a range of factors including specific policy design, interaction with related policies, and a jurisdiction's characteristics.

25 Parry, I., and Small, K. 2015. "Implications of Carbon Taxes for Transportation Policies". In Implementing a US Carbon Tax Challenges and Debates.
26 Anderson, S., Parry, I., Sallee, J., and Fischer, C. 2011. "Automobile Fuel Economy Standards Impacts, Efficiency and Alternatives". Review of Environmental Economics and Policy. Vol. 5. issue 1 pp. 89-108.

Table 1

Indicative impact of select policies on mitigation categories

Policy category	Policy examples	AVOID	SHIFT	IMPROVE	
		Activity reduction	Modal choice	Energy intensity	Fuel carbon intensity
Economic/pricing	**Carbon price** (ETS or tax)	High	High	Medium	Medium
	Vehicle pricing policies (e.g., Feebates, taxes on inefficient vehicles, and tax credits for fuel-efficient vehicles)	Low	Medium	High	Low
	Activity pricing policies (e.g., tolls, congestion pricing, PAYD insurance/registration rates)	High	Medium	Low	Low
Regulatory	**Vehicle efficiency standards** (fuel consumption or CO_2 based)	Low	Low	High	Medium
	Fuel standards (low carbon or renewable)	Low	Low	Low	High
Research, information, infrastructure and planning	**RD&D initiatives** (e.g., Research grants)	Low	Low	High	High
	Modal shift policies (e.g., access to, or subsidies for, public transport, new infrastructure)	High	High	Low	Low
	Urban Planning (compact development, green planning)	High	Medium	Low	Low
	Improving existing system efficiency (e.g., education, HOV lanes)	Medium	Medium	Low	Low

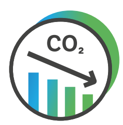
High *Medium* *Low*

As table 1 suggests, a portfolio approach will be needed to target all the abatement opportunities in the road transport sector. No single policy will be able to decarbonize the sector (or even achieve climate targets) on its own. Ultimately, the optimal suite of policies will be dependent on a range of factors, particularly the characteristics of the jurisdiction.

4.2 Role of carbon pricing

Section 3.2 highlights the limitations of carbon pricing, while section 4.1 emphasizes the benefits and role of other policies in reducing the road sector's emissions. While not perfect, carbon pricing has a role to play, particularly over the longer-term, including by:

- **Addressing imperfections in other policies:** A carbon price incentivizes agents to exploit all available opportunities to reduce emissions. This includes abatement opportunities not identified by governments, such as emerging technologies not currently deployed. Unlike regulatory approaches, it applies to all vehicles, not just new vehicles, and incentivizes behavioral changes in both producers (e.g., fuel producers and vehicle manufactures) and consumers. While policies such as vehicle efficiency standards have demonstrated to be effective at improving the efficiency of the vehicle fleet, they have their limitations. For example, efficiency standards generally only apply to new vehicles and can lead to an increase in activity (i.e., miles travelled) due to lower per mile costs, known as the "rebound effect".[27] Carbon pricing has "been shown to improve the efficiency of a regulation, especially by mitigating the rebound effects" caused by improved vehicle efficiency.[28] This could grow in importance with sustained low fuel prices, which can encourage consumers to drive more. The supporting role of carbon pricing is highlighted in the European Commission's Impact Assessment on Stepping up Europe's 2030 climate ambition, which indicates that applying a carbon price to road transport can "positively influence" existing policies, including CO_2 emission standards for vehicles.[29]



- **Decarbonizing supporting sectors:** An economy-wide carbon price can offer a pathway to decarbonization through decarbonizing supporting sectors, particularly electricity and hydrogen production. Promoting decarbonization in supporting sectors, such as incentivizing production of carbon-free electricity and alternative fuels, is a realistic and necessary pathway to help decarbonize the road transport sector. For example, the benefits provided by electric vehicles are only realized if electricity is supplied by less emissions-intensive sources.

27 *The rebound effect refers to responses to lower travel costs resulting from improved fuel efficiency. That is, fuel efficiency standards produce vehicles that travel further for a given amount of fuel. This lowers the fuel costs per mile and allows consumers to travel more miles for the same cost.*
28 *Axsen, J., Plötz, P. and Wolinetz, M. 2020. "Crafting strong, integrated policy mixes for deep CO_2 mitigation in road transport". Nature Climate Change. pp.1-10.*
29 *European Commission, 2020a. Impact Assessment on Stepping up Europe's 2030 climate ambition. Commission Staff Working Document SWD/2020/176.*

- **Promoting equity across sectors:** A uniform, economy-wide carbon pricing allows the market to identify and take-up the least cost solutions across the economy. This allows all sectors to face a uniform carbon price, promoting equity across sectors and consumers. Providing a long-term price signal allows producers and consumers to begin to factor carbon costs into road-transport decisions. Importantly, it allows the market, not governments, to determine if and when road transport can supply abatement at the lowest cost. The European Commission is currently considering the potential to expand the scope of the EU ETS to include other sectors, such as road transport. An inception Impact Assessment, released in October 2020, highlighted that expanding the EU ETS could "provide for harmonized economic incentives to reduce emissions" and would level the playing field across transport modes (e.g., road vs rail).[30]

- **Raising revenue:** As highlighted in section 3.1, carbon pricing has the potential to generate revenue for the government. Carbon revenue can be used to fund other essential polices such as investment in green infrastructure or RD&D.

5 Conclusions and next steps

This paper highlights the need for a portfolio approach to decarbonizing the road transport sector. While carbon pricing may not be the central mitigation policy for the road sector, it still has a role to play. This conclusion is supported by a recent paper in Nature Climate Change, which emphasizes that carbon pricing is "best viewed as playing a complementary role in an integrated policy mix".[31] The extent to which carbon pricing is incorporated into the policy mix is dependent on a jurisdiction's economic and political characteristics, noting that carbon pricing may be more politically acceptable in certain regions.

The following areas have been identified as possible areas for future work:

- **Road transport mitigation policy integration:** Building on the PMR and International Carbon Action Partnership's *ETS Handbook*, and the PMR's guide on *Carbon Pricing Assessment and Decision Making*, identify design features that help carbon pricing complement other road transport sector policies.
- **Identify and quantify the road transport sector impacts from carbon pricing in related sectors:** While explicit carbon pricing (particularly through an ETS) is relatively uncommon in the road transport sector, it is more prevalent in other related sectors, notably electricity. Identifying the issues (e.g., market distortions from pricing carbon in electricity used in electric vehicles/rail) and understanding the magnitude of the impacts for road transport from pricing carbon in related sectors would help understand the role of carbon pricing in decarbonizing road transport.
- **Develop guidance to promote coordination across multi-level governance jurisdictions:** Recognizing the important role of sub-national jurisdictions for decarbonizing road transport, develop guidance on actions to promote coordination and minimize overlap on policy choice, policy design, and governance.

30 European Commission, 2020b. Inception impact assessment on updating the EU emissions trading system.
31 Axsen, J., Plötz, P. and Wolinetz, M. 2020. "Crafting strong, integrated policy mixes for deep CO_2 mitigation in road transport". Nature Climate Change. pp.1-10.

- **Identify carbon pricing design elements to promote public acceptance:** Investigate carbon pricing design implementation options that may be more politically acceptable for road transport users. This could include more detailed investigation into the specific characteristics of various modes (e.g., light vehicles, heavy road freight, light and heavy rail, etc.).

- **Identify carbon pricing design elements to maximize non-climate benefits:** Explore how carbon prices in the road transport sector can be designed to maximize broader economic, social and environmental benefits, including health benefits through air pollution reduction.

- **Promote environmental tax reform:** Build on existing work by OECD, IMF and World Bank[32], to promote fuel tax reform to ensure the relative excise rates reflect the relative environmental and social damage caused by respective fuels and to promote broader economic, social and environmental outcomes.

- **Identify options to influence transport choices:** Explore the insights behavioral economics can offer in understanding consumer transport choices may also help policy makers find an appropriate role for a carbon price and design a more targeted policy instrument.

- **Raise profile of road transport in Paris framework:** There is need to increase the focus on road transport (particularly freight) in existing NDCs. Greater attention to the sector in the second round of NDC submissions can create a strong signal for national ministries and local governments to promote transport mitigation strategies and identify explicit transport emissions reduction targets. This could also be expanded to road transport-specific targets and plans in countries' long-term strategies.

- **Identify priorities for using revenue to support road transport decarbonization:** Discuss some of the advantages and limitations associated with using carbon pricing revenues to build transport infrastructure, improve access to low-carbon options for low and middle-income communities, and invest in low-carbon transport modes.

32 See for instance Heine, D. and Black, S. 2018. "Benefits beyond climate Environmental Tax Reform" in Pigato, M. (ed). Fiscal policies for development and Climate Action, World Bank, Washington DC

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Appendix A: Offset crediting and transport

"Carbon crediting" is the process of issuing tradable emission reduction units (or "credits") to actors implementing approved emission reductions avoidance (or sequestration) activities. Emissions reductions are quantified relative to counterfactual scenario (i.e., without the incentives provided by the crediting program). The carbon credits can then be used to "offset" emissions (e.g., reduce liabilities under an ETS or tax).

Implementing a carbon crediting program is generally more complex and administratively burdensome than an ETS or a tax, largely because of the difficulties in establishing a counterfactual scenario and establishing whether the emissions reduction project is additional to business-as-usual (known as "additionality").

Transport emissions reduction projects have particular complexities when establishing additionality. Some of the specific issues for transport projects in each of the four abatement categories identified in section 2.3 are summarized below:

1. **Activity reduction.** It is difficult to reward a project for reducing output because it is difficult to determine, with any certainty, whether such reductions are a result of unrelated factors (e.g., commercial reasons or market cycles).

2. **Modal choice.** Transportation mode is largely driven by factors separate from fuel (or carbon) prices, particularly mode availability (e.g., train line exists), integration with supply chains, and reliability of supply. For example, rail and shipping tend to be cheaper than road transport on a ton-mile basis. The availability of carbon credits might widen this gap, but is generally immaterial compared to fuel costs, and is difficult to establish whether credits are a primary driver.

3. **Energy intensity.** Improved intensity projects already have a strong financial driver because of the cost savings derived from improved energy efficiency that can lower fuel consumption for the same output (fuel is a significant cost of most transport operators). While other barriers to uptake may exist, the exitance of such barriers are difficult to demonstrate.

4. **Fuel carbon intensity.** While switching to alternative fuels in existing equipment may have potential to be incentivized by carbon credits, it is difficult to establishing that the credits are a primary driver. Establishing additionality for switching to next generation fuels like electricity or hydrogen is more difficult because the financial benefit provided by carbon credits is often immaterial compared to fuel and capital costs.

Transport projects also have specific complexities to develop projects with sufficient scale (e.g., to cover administrative costs, such as applications and verifications) and to implement adequate project measurement (e.g., need to measure and report ton-miles in addition to energy/emissions), which may not be currently measured at the required level of accuracy.

Further detail on policy considerations for generating carbon offset credits are available in the PMR's *Guide to developing a domestic crediting mechanism* (2021).

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