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Canada's transition to net zero emissions

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CANADA'S TRANSITION TO NET ZERO EMISSIONS

ECONOMICS DEPARTMENT WORKING PAPERS No. 1760

By Ben Conigrave

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Abstract/Resumé

Canada's transition to net zero emissions

Canada has an ambitious plan to reduce the economy's net emissions to zero by 2050. This will require a step change in mitigation action, with deep energy savings and near economy-wide replacement of fossil fuels with clean energy. Achieving this while minimising negative impacts on activity and living standards will be challenging. Canada is already using a range of policy instruments to propel its green transition – including carbon pricing, regulations, investment incentives, and public procurement of green technology. This Paper explores reforms that could make climate policies work better together to lock in both deep emissions reductions and strong economic growth. As with important efforts to prepare communities for the impacts of climate change, Canada's provinces and territories will play a key role in the country's green transition.

This Working Paper relates to the 2023 Economic Survey of Canada
https://www.oecd.org/economy/canada-economic-snapshot/

JEL codes: Q52, H32, H23, H31, Q58

Key words: Canada, climate policy, climate change, net zero, energy, green transition, carbon pricing, green investment

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La transition du Canada vers la neutralité carbone

Le Canada a adopté un plan ambitieux pour ramener à zéro les émissions nettes de gaz à effet de serre (GES) de son économie d'ici à 2050. Cela passera par un changement radical en matière d'atténuation du changement climatique, caractérisé par des économies d'énergie considérables et un remplacement dans la quasi-totalité de l'économie des combustibles fossiles par des énergies propres. Il ne sera pas aisé d'y parvenir tout en réduisant au minimum les effets négatifs induits sur l'activité et le niveau de vie. Le Canada utilise déjà toute une palette d'instruments d'action pour faire avancer sa transition écologique, notamment des systèmes de tarification du carbone, la réglementation, des incitations à investir ainsi que des achats publics de technologies vertes. Nous explorons dans ce document de travail des réformes qui pourraient améliorer l'efficacité globale des politiques climatiques, de sorte que leur mise en œuvre permette de conjuguer des réductions marquées et pérennes des émissions de GES et une croissance économique forte. Comme dans le cadre des efforts importants déployés pour préparer les collectivités aux effets du changement climatique, les provinces et territoires du Canada joueront un rôle clé dans la transition écologique du pays.

Ce document de travail concerne l'Étude économique du Canada 2023
https://www.oecd.org/fr/economie/canada-en-un-coup-d-oeil/

JEL codes: Q52, H32, H23, H31, Q58

Mots clés : Canada, politique climatique, changement climatique, neutralité carbone*, énergie,* transition écologique*, tarification du carbone, investissements verts*

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Canada's transition to net zero emissions

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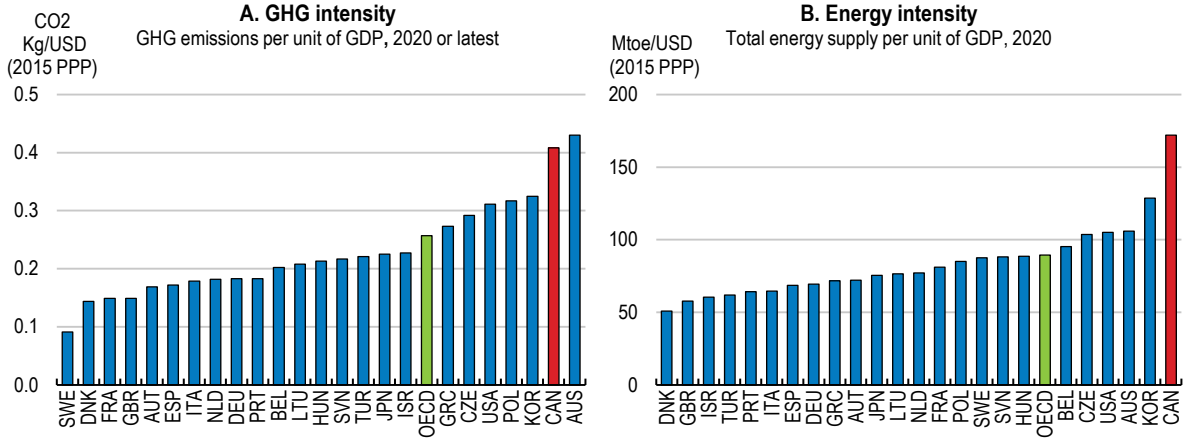
Canada's climate policy challenge

Deep emissions reductions are required for Canada to reach net zero

Canada's climate is changing rapidly already. Impacts from rising temperatures and associated extreme weather events are expected to increase in the coming years. Alongside efforts to prepare vulnerable communities for the effects of climate change, significant emissions reductions are required to meet Canada's international climate commitments. As a major producer of heavy crude oil and natural gas, Canada emits more greenhouse gases per person than most other OECD countries. Its weather and geography contribute to large energy requirements to heat homes in cold winters, and transport people and goods across large distances. This, too, drives up the emission-intensity of economic activity in Canada (Figure 1).

Figure 1. Economic activity in Canada is carbon and energy-intensive



Note: Panel A: Data exclude emissions from land use, land use change and forestry (LULUCF).
Source: OECD (2022), OECD Environment Statistics (database); and OECD (2022), OECD Economic Outlook (database).
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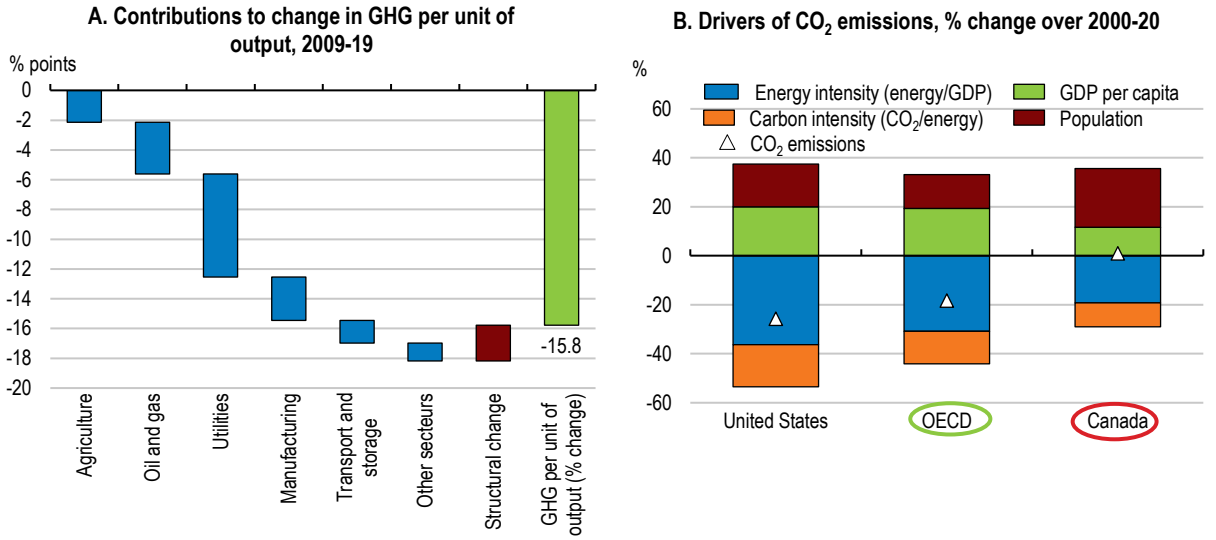
Designing effective climate policies is challenging in a federal country in which the costs and opportunities of a major green energy transition are likely to fall unevenly: some provinces have rich endowments of fossil fuel energy resources while others benefit from abundant hydroelectricity. The Government of Canada has a comprehensive climate strategy, but limiting the economic costs of achieving federal emissions targets will also require committed action by Canada's provinces. At the same time, forward-looking provinces have often led the way and provide a valuable testing ground for important national climate policies. Canada's federal system of government thus presents opportunities as well as challenges for the national climate policy agenda.

In recent years Canada has made progress on decoupling greenhouse gas emissions from economic growth. Replacement of coal-fired power with natural gas and renewable energy helped reduce the emission-intensity of electricity in the past two decades (Figure 2, Panel A). The energy-intensity of economic activity also declined, reflecting energy-efficiency improvements in homes and some heavy industries. But this progress has been offset by increased emissions from growth in Canada's resource and energy-intensive economy (Figure 2,Panel B).

A new climate plan – the 2030 Emissions Reduction Plan – is in place to accelerate Canada's net-zero transition (ECCC, 2022[1]). In keeping with the Paris Agreement, the federal government aims to achieve net zero greenhouse gas emissions by 2050. To stay on track there is an interim target of achieving a minimum 40% cut in emissions from 2005 levels by 2030 (Figure 3). Both goals are enshrined in law.

Figure 2. Emission-intensity declines only just offset the effect of growth in Canada's economy



Note: Panel A: An industry's contribution represents the change in its emissions intensity weighted by its share in economy-wide emissions. "Structural change" includes effects tied to changes in the composition of economic activity and movements in relative prices. Additive discrepancies from volume measures of industry value added will also be captured in this term. Panel B: Energy is total energy supplied. Emissions growth is disaggregated into contributions from changes in population, GDP per capita, energy intensity of output and emission intensity of energy.
Source: Statistics Canada; OECD, Environment database; OECD, Economic Outlook database; and IEA, IEA CO_2 Emissions from Fuel Combustion Statistics database.

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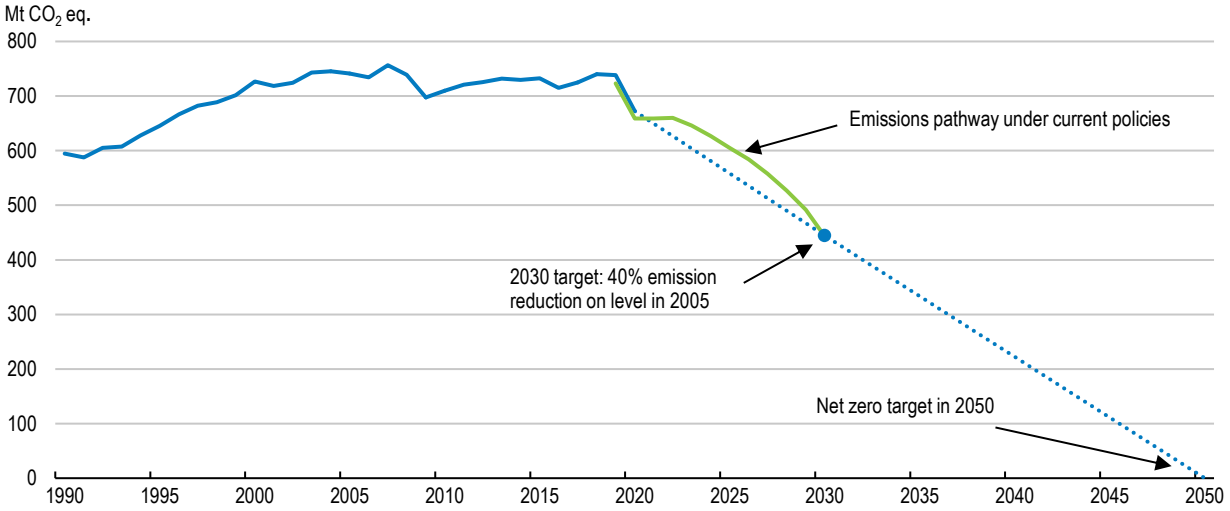
Serious ambition underpins the 2030 Emissions Reduction Plan. Achieving the plan's 2050 target of net zero emissions will require major energy savings and near economy-wide replacement of fossil fuels with clean energy. Residual emissions will need to be trapped and stored or offset with carbon sequestration

elsewhere. The government's ambition is backed up with an increasingly complete suite of mitigation policies.

Figure 3. Decarbonisation of Canada's economy requires a big improvement in performance

GHG emissions, including land use, land use change and forestry (LULUCF)



Note: The solid blue line shows historical GHG emissions. The dotted line shows the emissions reductions required to meet 2030 and 2050 targets along an indicative pathway, as described by the Climate Action Tracker. The emission pathway under current polices (the green line) is from Environment and Climate Change Canada (ECCC)'s *Greenhouse Gas Emission Projections* (May 2022). The dot shows the interim target for 2030 (maximum level of emissions targeted). Preliminary data are shown for 2020.
Source: Calculations based on OECD (2022), Environment: Air and Climate (database); Climate Action Tracker; and ECCC.

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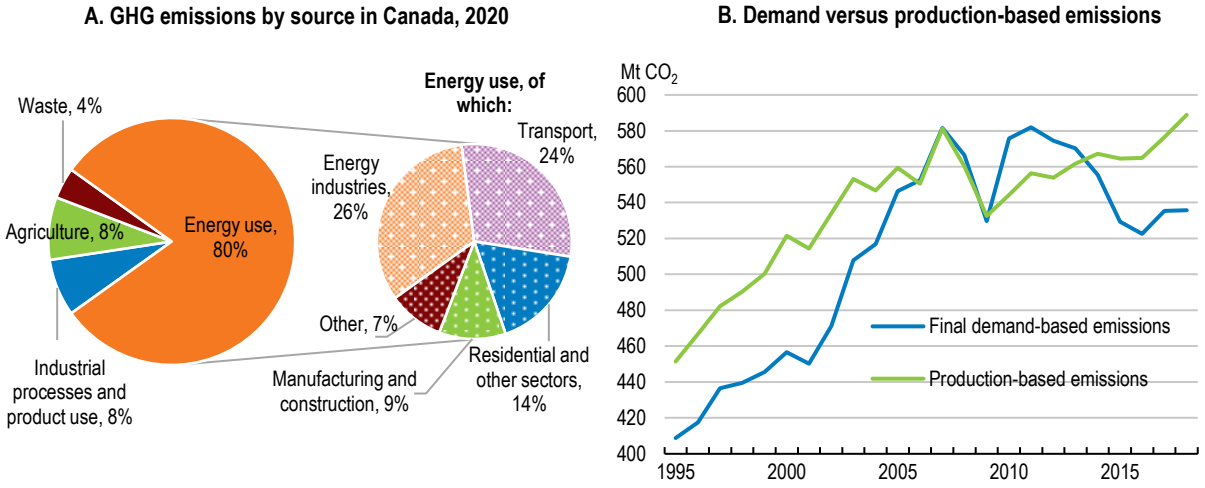
Energy lies at the centre of Canada's climate policy challenge

Canada is both a major oil and gas producer and a large consumer of clean electricity. Oil and gas exports contribute to large output-based emissions, but domestic energy use also contributes to the environmental impact of economic activity in Canada. There is a clear need to reduce emissions from burning fossil fuels – the source of four-fifths of Canada's greenhouse gas emissions (Figure 4). Green energy generation must ramp up to replace carbon-intensive electricity in provinces still dependent on conventional thermal power plants, while energy saving frees up capacity for the electrification of industry, transport and buildings. Significant investment will be needed to upgrade and adapt grids to accommodate greater electricity demand and more generation from intermittent energy sources.

Alongside efforts to decarbonise electricity, large-scale uptake of green technologies will be key to reducing energy consumption and carbon emissions from big-polluting industries. Among the technologies expected to contribute to Canada's net-zero transition are renewable power generation, carbon capture equipment, zero tailpipe emission vehicles and energy-efficient electric heat pumps for buildings. Governments can play an important role in shrinking barriers to research and development and reducing risks around green investments. The challenge is to design policies that achieve emissions abatement while minimising costs to economic activity and living standards.

Figure 4. Energy use is the main source of Canada's emissions



Note: Panel A: Emissions exclude land use, land use change and forestry (LULUCF). Panel B: The graph compares Canada's fuel-combustion emissions from production to estimates of carbon dioxide emissions embodied in final demand. Since 1995 Canada has mostly been a net exporter of greenhouse gas emissions: CO_2 emissions from production exceed those embodied in consumption and investment.
Source: OECD (2022), Air and Climate, Environment Statistics (database); and OECD (2021); and OECD (2021), Carbon dioxide (CO_2) emissions embodied in international trade (TeCO2) (database).

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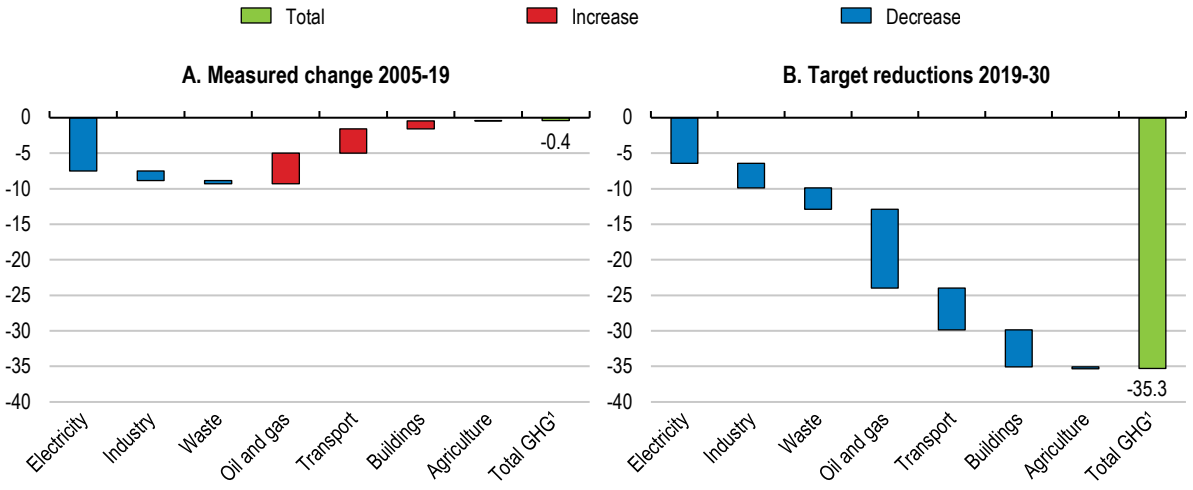
Effective systems for pricing greenhouse gas emissions are important if Canada is to minimise the economic cost of the green transition and capitalise on new growth opportunities. Rapid decarbonisation will require changes in behaviour by firms and households, with impacts on aggregate output and incomes. Designed well, market-based policies encourage greener choices while minimising other distortions to production and consumption. While price-based mitigation measures are appealing in terms of their efficiency, their impacts tend to fall unevenly – not just between firms, based on the carbon-intensity of their business, but also among households according to the energy and emission content of their spending. It is important to manage the distributional impact of policies such as carbon pricing, in particular to limit their impact on low-income households.

The first section of this Paper examines the Pan-Canadian approach to pricing carbon pollution. Changes are recommended to make carbon pricing systems work better. Like other countries, Canada has developed multiple other policy tools for accelerating emissions cuts. By using regulations, support for innovation and investment in green technologies and other measures to complement emissions pricing, policymakers can target a wider range of emissions and correct additional market barriers to low-cost abatement paths (Table 1). The second section of this Paper examines measures for decarbonising four sectors critical to reaching net zero in Canada: electricity, oil and gas, transport and buildings (Figure 5). These sectors are major contributors to Canada's greenhouse gas emissions. They also provide important inputs to production in the rest of the economy. Large emissions reductions will be needed across all four sectors for Canada to achieve its climate targets. The Paper does not examine all sources of greenhouse gas emissions in Canada. However, policies such as carbon offset schemes are explored which might extend mitigation incentives to hard-to-decarbonise activities, including agriculture and forestry. The Paper's third section considers adaptation measures that can reduce the impact of climate change in Canada.

Figure 5. Canada's GHG targets require deep emissions cuts in some sectors

Contribution to total GHG emissions change by economic sector, percentage points



1. Excluding LULUCF.

Note: Panel B: Contributions to total GHG reductions are calculated based on emissions reductions by economic sector factored into federal government modelling for the 2030 Emissions Reduction Plan.

Source: Environment and Climate Change Canada (2022[2]).

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Table 1. Interactions between carbon pricing and selected other federal climate policies

Measure	Sectors covered	Does the policy cover the same emissions as carbon pricing?	Does the policy complement carbon pricing?
Carbon offset credit system Started nationally in 2022.	Agriculture Land use	**No.** Targets emissions from land use change and other sources not covered by carbon pricing.	**Yes.** Creates an incentive for reducing emissions not covered by carbon pricing.
Clean electricity regulations Proposed.	Electricity	**Yes.** The measure would target emissions from conventional coal and natural gas power plants.	**Depends.** In competitive power markets, carbon cost pass-through drives decarbonisation with limited need for other tools. Most provincial power markets are regulated, impeding carbon cost pass-through. Clean electricity regulations can hasten phase-out of dirty energy.
Methane regulations Federal rules in force since 2020.	Oil and gas	**No.** Targets methane emissions from the oil and gas sector.	**Yes.** Until better methods are available to track methane emissions, regulations ensure companies take appropriate action to minimise emissions.
Oil and gas emissions cap Under consideration.	Oil and gas	**Yes.** Fuel combustion emissions generated in upstream operations. Oil and gas firms would pay higher carbon prices than other firms. Credit trade would be restricted.	**No.** Emission trading schemes (ETS) achieve low-cost abatement when price signals are uniform and firms in different sectors can trade credits. A single-sector ETS would be less efficient.
Tax support for carbon capture utilisation and storage (CCUS) Federal investment tax credit available from 2022.	Electricity Oil and gas Heavy industry	**Yes.** Fuel combustion emissions from oil and gas extraction and other industries.	**Depends.** Support is additional to carbon pricing incentives. Extra value comes from learning-by-doing. But total support from grants, tax credits, carbon pricing and CFR credits could over-reward CCUS as technologies mature.
Clean Fuel Regulations (CFR) In force nationally since 2022.	Oil and gas Transport	**Yes.** Emissions from production and use of transport fuels, including emissions throughout the transport-fuel supply chain.	**Yes.** Lowers barriers to development of low-carbon fuels. But CFR coverage of the lifecycle of fuel production and distribution overlaps with carbon pricing and can reduce efficiency.
Electric vehicle (EV) charging infrastructure support Ongoing.	Transport	**Yes.** Fuel combustion emissions from road transport.	**Yes.** In new markets, charger support re-inforces EV demand. Charger supply and EV demand are interdependent.
National model energy codes First code released in 2011.	Buildings	**Yes.** Direct emissions from natural gas heating. Indirect emissions from electricity use.	**Yes.** Addresses information problems – home purchasers know less about energy performance than builders.

Improving Canada's carbon pricing systems

Carbon pricing has a central place in Canada's emissions reduction plan

Among the policy instruments used to accelerate abatement in Canada, greenhouse gas emissions pricing has a central place in the national climate plan. Systems for pricing carbon can reduce emissions at lower cost than other policies. Designed well – with broad emissions coverage and uniform pricing signals across regions and sectors – such schemes minimise distortions to firm and household behaviour by treating emissions in a neutral way regardless of their origin. As well as encouraging use of cleaner energy and energy saving, carbon pricing improves the cost-competitiveness of green technologies.

Different carbon pricing schemes are in place in Canada's provinces and territories. This reflects the history of carbon pricing in Canada, which started with the introduction of carbon taxes and emissions trading schemes in the country's largest provinces before a pan-Canadian approach was implemented in 2019. The three main carbon pricing approaches used in Canada's provinces and territories are:

- **Carbon taxes** (price-based policy): A tax is levied on fossil fuels. The tax rate on a given fuel type is consistent with a fixed charge per tonne of CO_2 equivalent. This ensures rates reflect the emissions footprint of each fossil fuel subject to the tax. British Columbia is among the provinces and territories that have a carbon tax.
- **Cap-and-trade schemes** (quantity-based policy): A cap is set on annual greenhouse gas emissions covered by the system, with allowances issued to match the size of the cap. Firms submit free or purchased allowances to offset their emissions. Quebec has a cap-and-trade system linked with California.
- **Hybrid systems comprised of a fuel charge and large-emitter scheme**: A charge is levied on fossil fuels (fuel charge). Trade-exposed large emitters are exempt from the fuel charge but pay a charge, or submit credits, to account for emissions above set benchmarks (large emitter baseline-and-credit scheme). Credits are bought from other firms, earned by beating benchmarks, or generated through recognised offsets. In Canada, large-emitter schemes are often called "output-based pricing systems" (OBPS). In most provinces and territories, a hybrid scheme of this sort is in place (for example, see Box 1).

Quantity, price and hybrid approaches to emissions pricing have different strengths and weaknesses (Box 2). Under the Pan-Canadian approach to pricing carbon pollution, the federal government sets minimum national stringency criteria that all systems must meet. This aims to ensure systems are comparable and efficient. The criteria include a minimum carbon price for price-based systems. From CAD 20 in 2019, the price floor has risen to CAD 65 in 2023, helping increase average carbon rates in the economy at the same time as emissions coverage has expanded (Figure 6). The minimum carbon price is set to increase annually, reaching CAD 170 in 2030. This would bring carbon prices in Canada's provinces and territories within ranges considered necessary to keep countries on track for net zero emissions by the middle of this century (OECD, 2021[3]).

Box 1. Case study: application of federal fuel charge and provincial baseline-and-credit scheme in Alberta

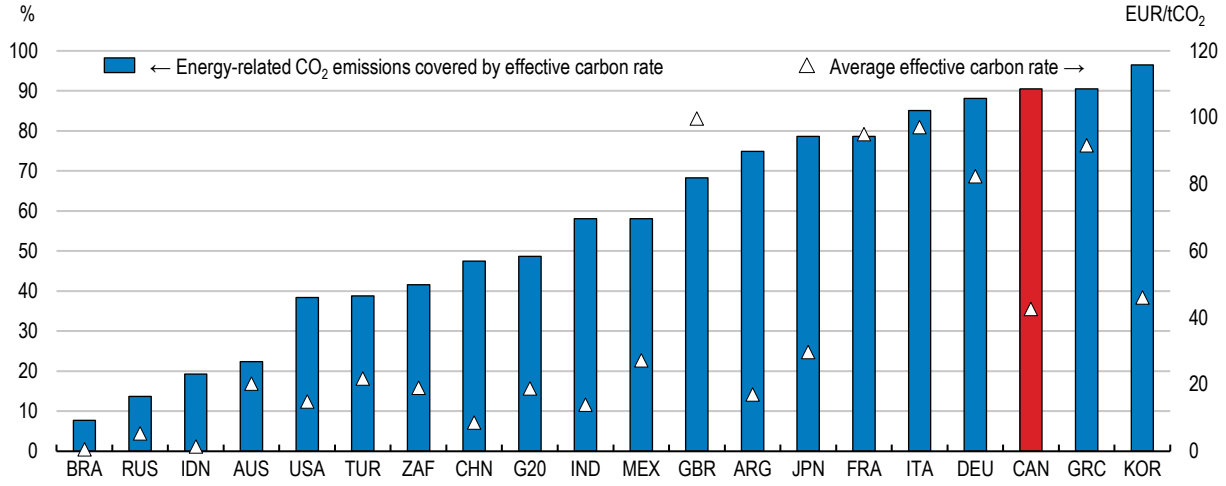
The federal carbon pollution pricing system is composed of a fuel charge and a baseline-and-credit system (the federal Output-Based Pricing System). One or both components of the federal system apply in provinces and territories that request it or do not meet national minimum stringency standards. The federal fuel charge applies in many of Canada's provinces and territories. Some jurisdictions have put in place provincial baseline-and-credit systems to protect large emitters from competitive pressures that might cause carbon leakage. Alberta is an example of a jurisdiction where the federal fuel charge applies together with a provincial large-emitter programme, called TIER ("Technology Innovation Emissions Reduction" Regulation). The following examples illustrate how these carbon pricing instruments apply to small and large emitters in Alberta:

Restaurant (small emitter): The business pays the federal fuel charge, generally indirectly, on natural gas used for heating and cooking, and on diesel for a van used in pickups and deliveries. As a small emitter, the firm does not participate in Alberta's baseline-and-credit scheme.

Cement factory (large emitter): The plant is a large trade-exposed emitter (generating over 100 000 tonnes of carbon dioxide each year). As such it is eligible to join TIER, Alberta's baseline-and-credit scheme. Its participation in TIER exempts the plant from paying federal fuel charge on fossil fuels used in production, including coal burnt to heat a cement kiln. But the firm faces TIER compliance obligations with respect to fuel combustion and industrial process emissions above its performance benchmark, which is set based on the plant's past emissions. In 2022 the plant exceeds its benchmark by 10 000 tonnes. For up to six of the ten thousand tonnes (60% of its compliance obligations) the plant can submit a combination of offsets and performance credits (which are generated by beating benchmarks in past periods or bought from other firms). The remaining 4 000 tonnes (the minimum allowed share in 2022 is 40%) are subject to the TIER Fund Price, which equals the federal carbon price floor (discussed below).

Source: Government of Alberta (2020[4]).

Figure 6. Effective carbon rates and emissions covered by carbon pricing in 2021



Note: Effective carbon rate is the price per tonne of CO_2-equivalent and reflects explicit carbon prices, fuel excise and fossil fuel subsidies.
Source: OECD Centre for Tax Policy and Administration.

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Box 2. Strengths and weaknesses of quantity and price-based mitigation policies

In **quantity-based policies** emissions are determined by a regulated cap. Trade in emission allowances encourages abatement where it can be done most cheaply. Cap-and-trade schemes improve certainty about emission reductions, but allowance prices can be volatile. Free allowances are distributed to firms at levels meant to drive abatement without pushing production and associated emissions across borders ("carbon leakage"). This requires reliable information on emissions, firms' ability to decarbonise production, and the extent to which local products compete with foreign-produced goods. It is challenging, in view of these broader considerations, to assign free allowances in ways that maintain incentives to innovate and reduce emissions.

Price-based policies offer more certainty over carbon costs and flow-through effects to other prices but expected emission reduction volumes are less predictable than in quantity-based schemes. With good modelling, a carbon price might be set to achieve a desired GHG reduction target. In practice, however, it can be challenging to predict the reaction of firms and households to carbon levies and other climate policies.

Hybrid schemes, as are common in Canada (Table 2), combine traits from price and quantity-based schemes, as well as their respective pros and cons. Large-emitter programmes exempt participants from charges on emissions below GHG-intensity benchmarks. This is designed to shield trade-exposed firms from competitive pressure that might cause carbon leakage.

Table 2. Carbon pricing schemes in Canadian provinces and territories in 2023

Type of scheme	Provinces and territories	Share of Canada's emissions in 2019
Carbon tax	British Columbia	9%
	Northwest Territories	0%
Cap-and-trade	Quebec	11%
Hybrid (fuel charge and large-emitter baseline-and-credit scheme)	Ontario	22%
	Alberta	38%
	Saskatchewan	10%
	Manitoba	3%
	New Brunswick	2%
	Nova Scotia	2%
	Newfoundland and Labrador	2%
	Prince Edward Island	0%
	Yukon	0%
	Nunavut	0%

Note: Most of Canada's greenhouse gas emissions are covered by hybrid schemes comprising a fuel charge and large-emitter programme.
Source: Government of Canada (2022[5])

Canada's carbon pricing framework prescribes other design criteria for provincial and territorial schemes. Minimum stringency requirements are defined relative to a federal "backstop" – a hybrid system consisting of a fuel charge and large-emitter scheme. The criteria to be satisfied include (Government of Canada, 2021[6]):

- **Minimum carbon price**: A price on carbon at least as high as the federal price floor. Caps in cap-and-trade schemes must be low enough to achieve abatement at least as significant as would be achieved with the carbon price.
- **Maintenance of the price signal**: Only sectors at risk of carbon leakage should be included in large-emitter baseline-and-credit schemes or given free allowances in cap-and-trade systems. Measures to directly offset the carbon price signal, such as point-of-sale rebates on fuel purchases, are not allowed. Also, there must not be an oversupply of credits that would cause credit prices to fall below the minimum carbon price.
- **Minimum emissions coverage**: Systems must cover a share of fuel combustion emissions at least as large as would be covered by the federal backstop. Large-emitter programmes also cover industrial process emissions.
- **Limits on offsets**: Offsets must deliver real and lasting emissions reductions.

Provincial carbon pricing schemes are assessed by Environment and Climate Change Canada for consistency with minimum stringency criteria; the next review is set to occur in 2026. Provinces and territories can choose to opt into the federal backstop rather than design their own carbon pricing systems. The backstop is imposed, in whole or in part, in jurisdictions failing to meet the minimum requirements. By July 2023, the full backstop system will apply in four jurisdictions (Manitoba, Prince Edward Island and the territories of Yukon and Nunavut). The federal fuel charge will apply together with a provincial large-emitter scheme in Newfoundland and Labrador, Nova Scotia, Ontario, Alberta and Saskatchewan. Wholly provincial or territorial systems apply in New Brunswick, Quebec, British Columbia and Northwest Territories.

A federal offset system was launched in 2022 (Government of Canada, 2022[7])). Projects that reduce net emissions earn credits that can be traded with firms participating in carbon pricing schemes. Offsets can also be used by businesses and governments across Canada – for example, to meet carbon-neutral commitments. Currently, credits can only be generated for projects involving landfill methane recovery and destruction. Other protocols are in development which could, in the future, enable offset generation from a wider range of projects. Designed to encourage abatement in activities not yet covered by carbon pricing, such as agriculture and forestry, the proposed protocols would cover emissions reduced through refrigeration systems, forest management, direct air carbon capture and storage, livestock feed management, and enhancing soil organic carbon. Gradual expansion of the offset scheme aims to ensure rewards are offered only for emission reductions that are real, additional, lasting and verifiable. Good governance systems will be important to verify offset projects and manage the credit supply.

Revenues from the federal carbon pricing system are returned to the provinces where they were collected. Direct proceeds are returned to governments of provinces and territories that voluntarily adopt the federal system. For provinces found not to meet federal stringency requirements, 90% of direct proceeds from the federal fuel charge are returned to residents in the jurisdiction of origin through quarterly lump-sum transfers (Box 3). The remaining 10% of direct federal fuel charge proceeds are used to support small businesses and Indigenous groups. In provinces found not to meet the stringency requirements for large-emitter systems, proceeds from the federal Output-based Pricing System are returned via federal programming to support clean technology projects in industrial and electricity sectors.

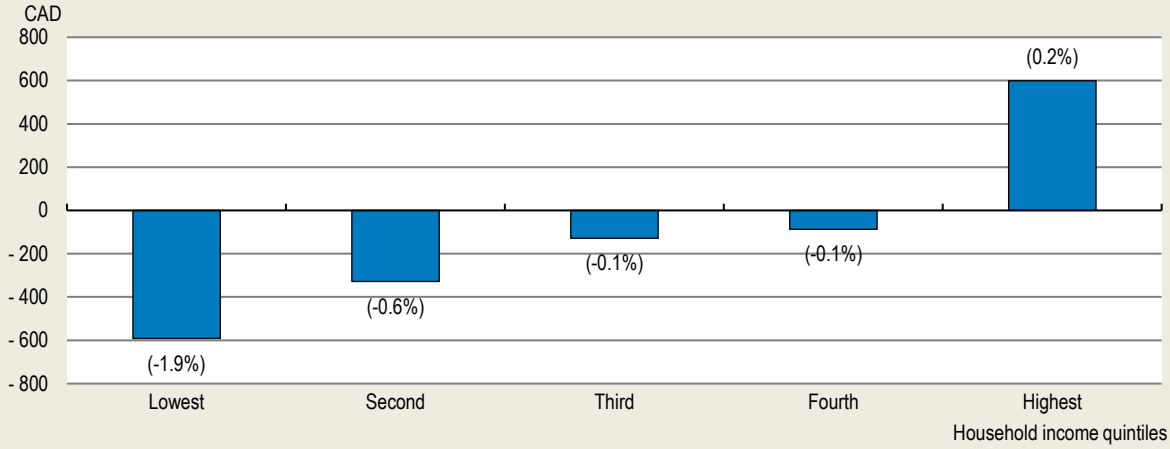
Policy objectives differ across Canada's revenue recycling schemes. Some provincial schemes, such as British Columbia's, have been used to mitigate the impact of climate policies on low-income households while shoring up public support for carbon pricing. Revenues from British Columbia's carbon tax have in the past been redistributed through support to firms, cuts to income taxes, property tax rebates to rural

homeowners, and targeted transfers to lower-income households (D'Arcangelo et al., 2022[8]). In Quebec, revenues from the sale of emission allowances help fund adaptation and mitigation measures.

Box 3. Mitigating the distributional effects of carbon pricing by recycling revenue

In provinces where the federal fuel charge has been imposed, households receive quarterly lump-sum transfers called Climate Action Incentive (CAI) payments. Households able to reduce their spending on carbon-intensive goods still receive the same CAI payments, which vary by household size and number of children. Once rebates are taken into account, less well-off households typically benefit from the carbon pricing system: rebates are generally large relative to the carbon cost of their consumption. Higher income households, who tend to consume more, are slightly worse off on average: rebates are small relative to the larger carbon cost of their spending (Figure 7). Without CAI payments, the burden of carbon pricing would instead fall more heavily on low-income households, who spend a larger share of their income on energy. CAI payments likely reinforce public support for carbon pricing, which is strongest when policies are perceived as fair (Dechezleprêtre et al., 2022[9]). Returning revenues to where they are collected also avoids redistributing income between provinces. This would penalise regions more reliant on fossil fuels, where past resistance to federal carbon pricing has been strongest.

Figure 7. Estimates of household net carbon costs in 2030-31: Ontario



Note: Net cost refers to the federal fuel charge and GST paid less rebates received. Negative cost indicates that rebates exceed gross carbon costs. Figures in brackets show net cost as a share of disposable income. The Office of the Parliamentary Budget Officer (PBO) estimates that carbon costs would be larger if second-round economic impacts of carbon pricing are taken into account; these estimated impacts do not, however, account for the costs of climate inaction or for potential economic benefits from the move to a low-carbon economy in terms of innovation, investment and jobs.
Source: PBO (2022[10]).

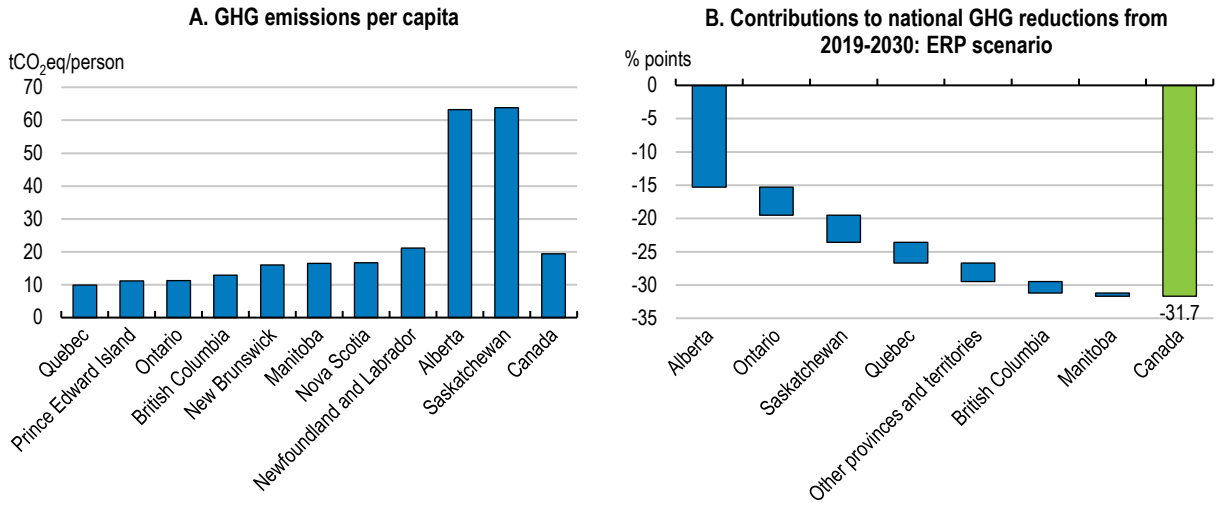
StatLink 2 https://stat.link/ylqer8

Stringency criteria for carbon pricing systems will need to be strictly enforced

In past years, some provincial carbon pricing schemes have done too much to shield large emitters from carbon costs. Entry to provincial large-emitter schemes has not always been limited to trade-exposed producers, as federal rules require. For instance, natural gas-fired power plants participate in Alberta's large-emitter scheme despite being shielded from competition by their remoteness to other plants, capacity limits on power imports, and transmission costs involved in importing electricity from other regions (Olmstead and Yatchew, 2022[11]). Entry into large-emitter schemes reduces participants' carbon costs and

thus incentives for major green investments. To improve the efficiency of carbon pricing systems, it is important that participation in such schemes is reserved for activities subject to genuine carbon leakage risk. Some provinces contribute such a large share of national emissions that inadequate enforcement of carbon pricing rules could have a big impact on progress towards Canada's emissions targets (Figure 8).

Figure 8. Meeting Canada's GHG targets requires deep emission cuts in fossil-fuel rich provinces



Note: GHG emissions exclude LULUCF. Panel B: Provincial emissions projections are based on a scenario reported in Canada's 2030 Emissions Reduction Plan, incorporating the impacts of major announced and proposed climate policies. Exclusion from the scenario of minor policies, and a 30 Mt reduction in GHG due to LULUCF, together contribute to a discrepancy with the Canadian government's target of a 40% reduction by 2030. "Other provinces and territories" includes New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador, Northwest Territories, Nunavut and Yukon.
Source: Statistics Canada and ECCC (2022[1]).

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There is scope to continue tightening carbon pricing rules

Tighter federal stringency criteria in force from 2023 should help close some past loopholes. In addition to setting out the path of carbon price rises through to 2030 and a minimum coverage benchmark, the strengthened criteria require that large-emitter programs cover industrial process emissions (Government of Canada, 2021[6]). The Government of Canada also introduced a ban on point-of-sale carbon pricing rebates. Together, these changes should amplify carbon pricing signals. The strengthened carbon pricing rules complement broader federal efforts in recent years to phase out inefficient fossil fuel subsidies (OECD, 2020[12]).

More work can be done to build on recent progress to harmonise the stringency of provincial carbon pricing systems. Gaps in federal design criteria still allow provinces to choose categories of emissions to exempt from pricing – such as diesel used on farms, or aviation fuel. Stricter rules could harmonise coverage across provinces. A longer-term aim should be to expand coverage to emissions currently outside the scope of most provincial carbon pricing schemes, such as methane from oil and gas operations (discussed below). Such efforts would improve the efficiency of carbon pricing nationally.

Work remains to be done to address important differences in the design of provincial large-emitter schemes. A 2021 review found that disparate design features contribute to gaps in average carbon costs across provinces within industries (Canadian Institute for Climate Choices, 2021[13]). National rules still allow provinces to determine entry criteria for their large-emitter schemes. Provinces also set the performance benchmarks that determine the share of participating firms' emissions subject to a carbon price. Unlike the federal large-emitter scheme – which pegs many industry benchmarks to an average

emissions intensity for facilities producing similar products – a common approach in provincial schemes is to set benchmarks based on a firm's own past emissions (Table 3). Setting the benchmark too high can reduce abatement incentives for low-performing businesses. At the same time, rewards are reduced for high-performing facilities. A better approach is to prescribe benchmarks based on a high-performance standard, independent of a firm's own past performance. In the EU Emissions Trading System, benchmarks are based on the average emissions of the top 10% best-performing producers of a given product. Provided there is no constitutional impediment, Canada's national stringency criteria could be tightened to require use of such methods in provincial carbon pricing systems. Benchmarks from other countries might be adapted in cases where only one producer of a given product exists in Canada. Alberta is considering use of global benchmarks for such situations (Government of Alberta, 2022[14]).

Table 3. Characteristics of selected carbon pricing schemes affecting large emitters in 2022

	Federal	Alberta	British Columbia	Ontario	Quebec
System name	Output-Based Pricing System	Technology Innovation and Emissions Reduction	Carbon tax	Emissions Performance Standards	Cap-and-Trade System
System type	Baseline-and-credit	Baseline-and-credit	Carbon tax	Baseline-and-credit	Cap-and-trade
Emission threshold for mandatory participation	50 000 tonnes	100 000 tonnes	10 000 tonnes	50 000 tonnes	25 000 tonnes
Benefits of participation	Fuel charge exemption	Fuel charge exemption	Reduced carbon tax for high performers	Fuel charge exemption	Participation in carbon market
How are benchmarks determined?	Activity-specific benchmarks	Facility specific and high-performance	Sector benchmarks apply in the large-emitter incentive programme	Facility and sector benchmarks	Mainly facility benchmarks
What % of obligations can be met with credits?	Up to 75%	Up to 60%	NA	No offsets. No limit on credits.	Up to 8% for offsets
Time limit on using credits and allowances?	5 years	9 years	NA	5 years	3 years
Are there limits on credit volumes or minimum prices?	✓ Cap on no. of credits	NA	NA	✓ Facilities earn credits worth max 5% of benchmarks	✓ Holding limit on allowances. Min price.
Is credit trading allowed?	✓ Within backstop provinces	✓ Within province only	NA	✓ Within province only	✓ Within province and with California

Note: The federal OBPS is part of the federal "backstop", which also includes the federal fuel charge. Participants in the OBPS do not pay the fuel charge on emissions below their performance benchmarks. Participants in the provincial baseline-and-credit schemes of Alberta and Ontario – where the federal fuel charge also applies – similarly do not pay fuel charge on emissions below their performance benchmarks. Settings in some provincial carbon pricing systems are set to change in 2023, including to comply with tighter federal benchmark criteria.
Source: Government of Alberta (2020[15]), Government of Canada (2022[16]), International Carbon Action Partnership (2022[17]), Government of Ontario (2021[18]), Government of British Columbia (2022[19]), Canadian Institute for Climate Choices (2021[13]).

Federal guidelines suggest that, among other mechanisms to support price predictability and market stability, baseline-and-credit systems should tighten performance standards for large emitters over time (Government of Canada, 2021[6]). Such approaches feature already in the federal baseline-and-credit system and in most provincial large-emitter schemes. Benchmark tightening reduces the risk of credit oversupply, which can cause credit prices to fall below the national carbon price floor, contravening federal benchmark requirements. Gradual lowering of benchmarks could avoid abrupt cost increases that might

push firms to relocate carbon-intensive production. At the same time, tighter standards would ensure abatement incentives strengthen predictably over time. The EU Emissions Trading System updates benchmark values at five-yearly intervals, with consistent annual reductions in performance standards in intervening years. Stepped increases in carbon rates, driven by tougher benchmarks and planned increases in the carbon price floor, will be important for spurring the significant green investments needed to decarbonise production in Canada.

There is a need for common rules on carbon credits and better credit tracking

Active management of credit markets may be needed to preserve uniform carbon pricing signals. Emissions trading systems can deal with shocks to credit demand by setting floors and ceilings around credit prices (a "price collar"). Active management of the credit supply can be used to the same effect. Europe's Market Stability Reserve performs this role in the EU ETS. In Canada, limits on the price or use of credits apply in some provinces. For instance, Quebec's cap-and-trade scheme imposes an auction reserve price as a floor on allowance prices. Such policies help to avoid credit gluts, as do limits on how long participants can hold onto credits (Table 3). Updated federal guidelines recommend that provinces set limits on credit use and maintain registries for tracking compliance units in large-emitter schemes (Government of Canada, 2021[6]). Provinces are required to ensure that credit supply does not exceed demand such that credit prices broadly track the minimum carbon price. However, it can be difficult to monitor credit prices, which are not reported on or publicly available. Centralised tracking of credit supply and prices would aid credit management and support compliance with federal benchmark requirements. This might be done by expanding the role of the federal credit and tracking system (CATS).

Harmonising the stringency of Canada's carbon pricing systems would pave the way for more credit trade between jurisdictions. Trade is currently limited to the backstop provinces (where participants trade credits with facilities in other participating provinces) and Quebec (where trading is possible with California). The federal government is considering enabling greater credit trade between provinces with compatible systems – for instance, all jurisdictions using large emitter schemes. This could open up lower-cost abatement paths for Canada.

Greater confidence in future prices would strengthen carbon price signals

Confidence in higher future carbon prices will be important for stimulating green investments. As in other countries, the stringency of future climate policies, including carbon pricing, will depend on decisions by future governments. Regulatory uncertainty can mean that firms delay costly capital expenditure or underinvest in green technology (see, for example, Berestycki et al. (2022[20])). Canada's federal government is proposing to use a new Canada Growth Fund to offer "contracts for difference" as a means for reducing carbon cost uncertainty. Under such agreements, the government would compensate a firm making a major green investment if the carbon price turned out lower than planned. Similarly, the business would return surplus gains to the government if the carbon price turned out higher than expected. Similar arrangements are used to promote investments in clean electricity by removing risk around volatile power prices, including in the United Kingdom (D'Arcangelo et al. (2022[8]), OECD (2022[21]). Once put into practice – ideally initially for a small range of investments for which abatement can be estimated and verified – carbon-price contracts for difference should improve the investment climate for green technologies in Canada, motivating abatement action in carbon-intensive sectors. Consistent climate policy messaging from federal and provincial governments is also needed (Box 4).

Box 4. Climate policy and shared powers in Canada's constitution

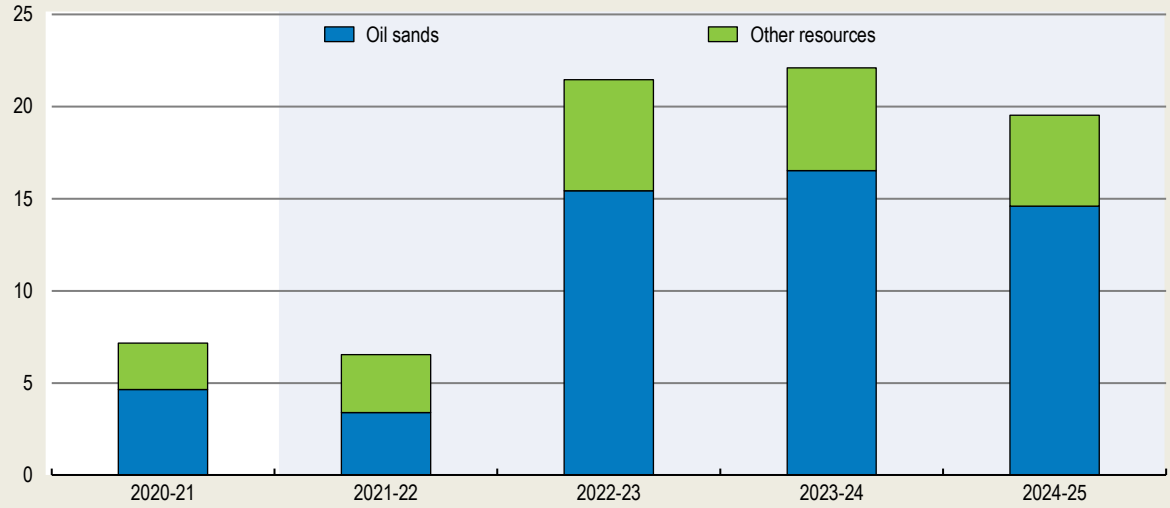
Alignment of climate aims between the federal and provincial governments will be essential for early and effective action to mitigate emissions. Major green investments, such as installing carbon capture technology and green energy systems, involve large capital costs and long lead times. To ensure important projects start now, producers need clear signals about the future direction of policy. Signals have been confused in recent years by the divergent climate aims of Canada's federal government and provinces heavily dependent on fossil fuels – some, such as Alberta, derive a large share of their revenue from resources, particularly when oil prices are high (Figure 9).

Legislative powers for government action on environmental protection, including climate policy, are split between Canada's federal and provincial governments. Climate policy progress in recent years has seen the federal government take on a larger role, including with respect to carbon pricing and the regulation of methane emissions from oil and gas extraction.

Some provinces have actively resisted what they assert is federal overreach in climate policy. Alberta, Saskatchewan and Ontario challenged the constitutionality of the federal *Greenhouse Gas Pollution Pricing Act*, which sets minimum national stringency standards for greenhouse gas emissions pricing systems. They argued that, in legislating the Act, the federal Parliament stepped outside the bounds of its powers. Canada's Supreme Court rejected this argument in 2021. A majority of the country's top court found that Parliament had jurisdiction to enact the law as a matter of national concern under the peace, order and good government clause of section 91 of Canada's Constitution Act*, 1867*.

Figure 9. Alberta benefits from resource revenues

Resources % of provincial government revenue in Alberta



Note: The western provinces of Alberta and Saskatchewan are home to Canada's oil sands industry. High crude oil prices underpin provincial budget projections of strong resources revenues in coming years. The shaded area indicates forecasts.
Source: Government of Alberta (2022[22]), Supreme Court of Canada (2021[23]).

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Continuing to promote international cooperation on price and non-price-based carbon mitigation policies

Carbon leakage risks may increase with higher carbon costs in coming years. Risks of carbon leakage are greater in Canada in view of the absence of emissions pricing in key regional trading partners, and greater recourse in the United States to technology support measures, including under the recent *Inflation Reduction Act* (IRA). In the *Fall Economic Statement 2022* Canada promised to introduce significant additional technology support to mitigate the impact of the IRA on Canada's cost-competitiveness. Canada has also been exploring carbon border adjustments. The European Union will phase in a Carbon Border Adjustment Mechanism (CBAM) from October 2023. Designed to reduce the cost advantage of carbon-intensive imports not subject to stringent emissions pricing, the measure also aims to encourage cleaner industrial production in non-EU countries. In Canada, implementing carbon border adjustments could be challenging, at least in the near term. Such policies would need to account for significant differences across Canada's provincial carbon pricing systems (Boessenkool et al., 2022[24]).

Canada continues to promote international action to address the shared challenge of climate change. Cooperation is important to expand abatement action worldwide and reduce the toll of mitigation policies on individual economies. Countries like Canada with advanced climate policy frameworks also play an important role in sharing their knowledge and experience. Other federations could draw lessons from Canada's successful development of a national framework for emissions pricing, which accommodates differences in sub-national schemes while upholding a common price floor. The Pan-Canadian approach to pricing carbon pollution may also provide a model for international efforts to increase the share of greenhouse gas emissions subject to pricing policies (Parry, 2021[25]).

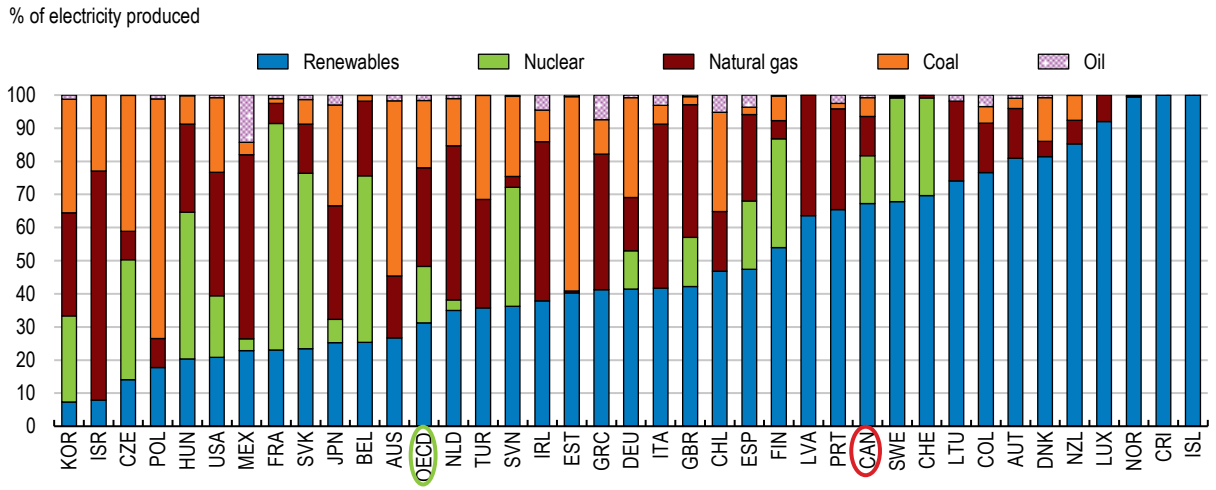
Canada is also heavily involved in global efforts to tackle methane emissions (discussed below) and is a member of the International Platform on Sustainable Finance. The federal government is developing a framework for mandatory reporting of climate-related financial risks based on the international Task Force on Climate-related Financial Disclosures framework. In the 2022 Budget the government announced that federally-regulated financial institutions will be required to publish climate disclosures from 2024. This initiative, which is to be introduced in phases, will help attract green investments to key sectors and contribute to international efforts to scale up environmentally sustainable finance. The OECD's Inclusive Forum on Carbon Mitigation Approaches provides Canada and other countries with a forum to share experience across a range of climate policies.

Accelerating decarbonisation of electricity

Electricity is greener in Canada than in many other OECD countries (Figure 10). Provinces including Quebec and British Columbia benefit from large hydroelectric capacity. Retirement of coal power in Ontario (from 2003 to 2014) and Alberta (due to end in 2023) has further reduced the carbon-intensity of electricity in Canada. Emissions from the sector declined 41% in the past decade despite a 12% increase in generation. The federal government aims to drive remaining net emissions from electricity generation to zero by 2035.

Figure 10. Electricity generation is greener in Canada than in most other OECD countries

Electricity generation by energy source, 2021



Note: Renewables include biofuels and waste, hydro, wind, solar, geothermal and other energies.
Source: IEA (2022), Electricity Information (database).

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Provinces need new sources of zero-carbon electricity to replace outgoing emission-intensive power and prepare for new demands on grids. Feasible low-cost hydropower projects will be hard to find (IEA, 2022[26]). In contrast, despite input price pressures in 2022, the cost of renewable wind and solar electricity generation is significantly lower than a decade ago (BloombergNEF, 2022[27]). Provinces are expected to increasingly exploit wind and solar power potential in coming years, backed with government-sponsored tenders for clean energy generation. From 5% of total supply in 2019, the Canada Energy Regulator (CER) projects that solar and wind power will together comprise 15% of electricity generated in Canada in 2035. This would require generating 1 additional terawatt-hour (TWh) of solar power (enough to power roughly 100 000 homes) every year for 15 years. An extra 4.2 TWh of wind power would be needed annually. The decade to 2020 saw much smaller average additions of 0.2 TWh of solar and 2.7 TWh of wind power each year.

Cost-effective policies are needed both to encourage new supply of clean electricity and to moderate demand. In addition to support for renewable electricity generation, Canadian governments are sponsoring the development of small modular nuclear reactors. Policies to moderate power demand in peak periods can reduce the additional generation capacity needed to electrify transport, industry and heating. Large investments in provincial electricity grids will still be needed to accommodate new sources of demand and more intermittent electricity generation. A clear priority in this context is to pursue low-cost regional solutions to electricity storage.

Effective collaboration between governments can shrink the cost of decarbonising electricity. The Government of Canada influences provincial power market dynamics through federal climate policies – including carbon pricing and regulation of emissions from coal power stations. But Canada's provinces have policy responsibility for their own electricity systems.

Barriers to competition and trade can raise the cost of the green energy transition

Competition is limited in most provincial electricity markets. In provinces rich in hydropower, the scale of infrastructure required for generation, transmission and distribution can create natural monopolies. In such markets, generation and transmission are dominated by a vertically integrated, publicly-owned utility

(Table 4). Wholesale prices are commonly regulated based on cost of service, which is low in provinces with abundant hydropower. Returns from selling higher-priced exports also help sustain below-market regulated rates for customers in major power-exporting provinces. Low local prices particularly benefit energy-intensive businesses and high-income households with large power consumption.

In most regions, total trade (domestic and international) is small relative to local supply. Moreover, trade between Canadian provinces is often smaller than power sales to US markets. A small number of interconnectors limit east-west power transmission between Canadian provinces, which have tended to prioritise self-sufficiency in supply. In contrast, major electricity-exporting provinces are well connected to nearby US markets, which can require smaller transmission costs to reach.

Table 4. Selected characteristics of provincial electricity markets

	Main electricity source (2019)	Competitive or regulated generation?	Public ownership of main generators? (1)	Independent transmission?	Retail prices market-determined?
Ontario	Nuclear	Hybrid (2)	Yes	Yes	Mainly regulated for residential
Quebec	Hydro	Regulated	Yes	No	Regulated
British Columbia	Hydro	Regulated	Yes	No	Regulated
Alberta	Gas and coal	Competitive	No	Yes	Market determined
Manitoba	Hydro	Regulated	Yes	No	Regulated
Saskatchewan	Coal and gas	Regulated	Yes	No	Regulated
Nova Scotia	Coal and gas	Regulated	No	No	Regulated
New Brunswick	Nuclear and hydro	Regulated	Yes	No	Regulated
Newfoundland and Labrador	Hydro	Regulated	Yes	No	Regulated
Prince Edward Island	Wind	Regulated	No	No	Regulated

Note: (1) Ownership status of main utility company; (2) Contract guarantees and fixed prices provided to generation companies affect wholesale prices. End users can elect to pay regulated prices.
Source: Luu (2016[28]), IEA (2022[26])

Benefits from low regulated electricity prices are offset by some important drawbacks. Access to low-cost electricity can encourage uptake of electric vehicles and heating, with direct environmental benefits in provinces with low-carbon electricity. But efficient carbon pricing policies in Canada's provinces and territories already improve the cost competitiveness of green technology, reducing the need for low regulated power prices to stimulate green investments. Moreover, by insulating local electricity prices from market forces, provincial price regulations encourage heavy energy use. Increased local power consumption in turn reduces provinces' capacity to export low-carbon electricity to other markets, where it might displace fossil fuel generation and reduce regional emissions.

For provinces still using fossil fuel power, heavy power-market regulation may also impede pass-through of carbon prices to electricity consumers (Box 5). The participation of conventional thermal generators in large emitter schemes – which reduce their exposure to carbon costs – directly reduces the impact of carbon pricing on generation costs. The translation of (smaller) generation-cost increases to power prices is in turn diluted by regulations tying wholesale prices to average costs of supplying power. In contrast, in a competitive electricity market – with prices aligned with the cost of supplying the last unit of power to the grid – carbon cost pass-through can be large in periods where fossil fuel generation is needed to balance electricity supply and demand (IEA, 2020[29]). A highly efficient mechanism in a competitive environment, carbon cost pass-through ideally reduces the dispatch of carbon-intensive electricity, improves the cost-competitiveness of clean energy, and encourages power conservation in peak demand periods. Such

channels can break down in heavily regulated markets, necessitating additional, higher-cost policy interventions to stimulate clean energy investment and encourage energy efficiency.

Implicit barriers to electricity trade between provinces may also influence costs of generating and storing power in the years ahead. Impediments to inter-provincial trade and competition in generation make it less likely that new clean electricity projects occur where returns are greatest. Segmentation of provincial power markets could also limit potential low-cost solutions to storing increased volumes of intermittent energy.

Box 5. Carbon cost pass-through in regulated electricity markets

In competitive power markets, carbon pricing can be a powerful tool for improving the profitability of zero-carbon electricity and driving high-emitting power off the grid. Once in place, a carbon tax or emissions trading scheme increases costs for traditional coal and natural gas generators. Pass-through of such costs is strong, particularly in periods of high demand (Fabra and Reguant, 2014[30]). So long as some fossil fuel energy remains, suppliers of renewable electricity benefit over time from higher prices. Paired with instruments to shield low-carbon electricity providers from wholesale price volatility, this can encourage investment in solar and wind power, hastening the exit of high-priced fossil fuel power from the grid. The United Kingdom largely phased out its remaining coal power in the 2010s this way, aided by public tenders for wind power (Blanchard and Tirole, 2021[31]). In Alberta's competitive electricity market, carbon pricing helped raise the marginal cost of producing coal-fired electricity relative to lower-carbon power sources, increasingly displacing coal from electricity generation in recent years (Olmstead and Yatchew, 2022[11]). The same forces are impeded in regulated electricity markets, as exist in most other Canadian provinces. Regulation of dispatch and wholesale prices can reduce competitive pressure from carbon taxation on carbon-intensive generators. Coal and natural gas power plants also benefit in some provinces from participation in large-emitter programs, which exempt a portion of their emissions from carbon pricing. In provinces with cost-of-service based power pricing, this further dilutes the effect of carbon prices on electricity bills (Dion, 2018[32]). At the same time, retail power price regulation can erode energy-saving incentives for customers (IEA, 2020[29]).

Policies to encourage supply of clean electricity

A long-run transition to market-based electricity pricing could improve power-market efficiency in heavily regulated provincial power markets. Exposure to market prices – for instance, through increased trade and competition – could cause power prices to rise in some Canadian provinces (Luu, 2016[28]). Local utilities' profits would increase as a consequence. Higher returns to private investment in zero-carbon electricity generation, if coupled with protection from price volatility, could in turn reduce the need for governments to support renewable energy supply through additional measures. Aided by grid investments and steps to pool power with competitive markets in the region, provincial reforms to liberalise electricity markets could also help encourage energy saving, freeing up more clean power for export (Box 6).

Greater electricity trade between provinces could facilitate increased competition in markets currently dominated by a small number of large generators. In considering long-run integration of currently separate power markets, Canadian provinces could look to models of production pooling in other OECD countries (Box 7). An added benefit of greater electricity trade would be to lower power storage costs in regions increasingly reliant on intermittent energy. Hydro reservoirs can reduce the need for expensive batteries by balancing supply and demand once solar and wind power has been deployed (see, for example, Brinkman et al. (2021[33]), Dolter and Rivers (2018[34])).

Increased electricity trade between proximate markets can also improve access to clean electricity in provinces still reliant on fossil fuel energy. Completion of the "Atlantic Loop" system, connecting Quebec with electricity markets in Atlantic Canada, aims to capture such gains. Provinces should continue to pursue bilateral efforts to pool production and invest in cross-border transmission links where feasible in

view of geographic constraints. Federal government infrastructure investments support such projects. Distance between markets influences the cost and viability of expanding inter-provincial transmission links. Recently completed projects provide a reminder of the upfront capital costs of linking grids. For instance, the 80km Birtle transmission line connecting a generator in western Manitoba to the Manitoba–Saskatchewan boundary was estimated in 2019 to cost CAD 69.3 million (Manitoba Hydro, 2020[35]). This implies a cost per kilometre of almost CAD 900 000. Capital costs naturally increase with larger and more complicated projects.

Rising generation and transmission costs in coming years will provide opportunities to reassess pricing policies. Integrating intermittent power generation will require investment in distribution and storage infrastructure to ensure stability of supply. Transmission upgrades are also needed across Canada (IEA, 2022[26]). This will drive up costs of getting electricity to customers. Utilities should anticipate these trends by reassessing inefficient pricing methods now.

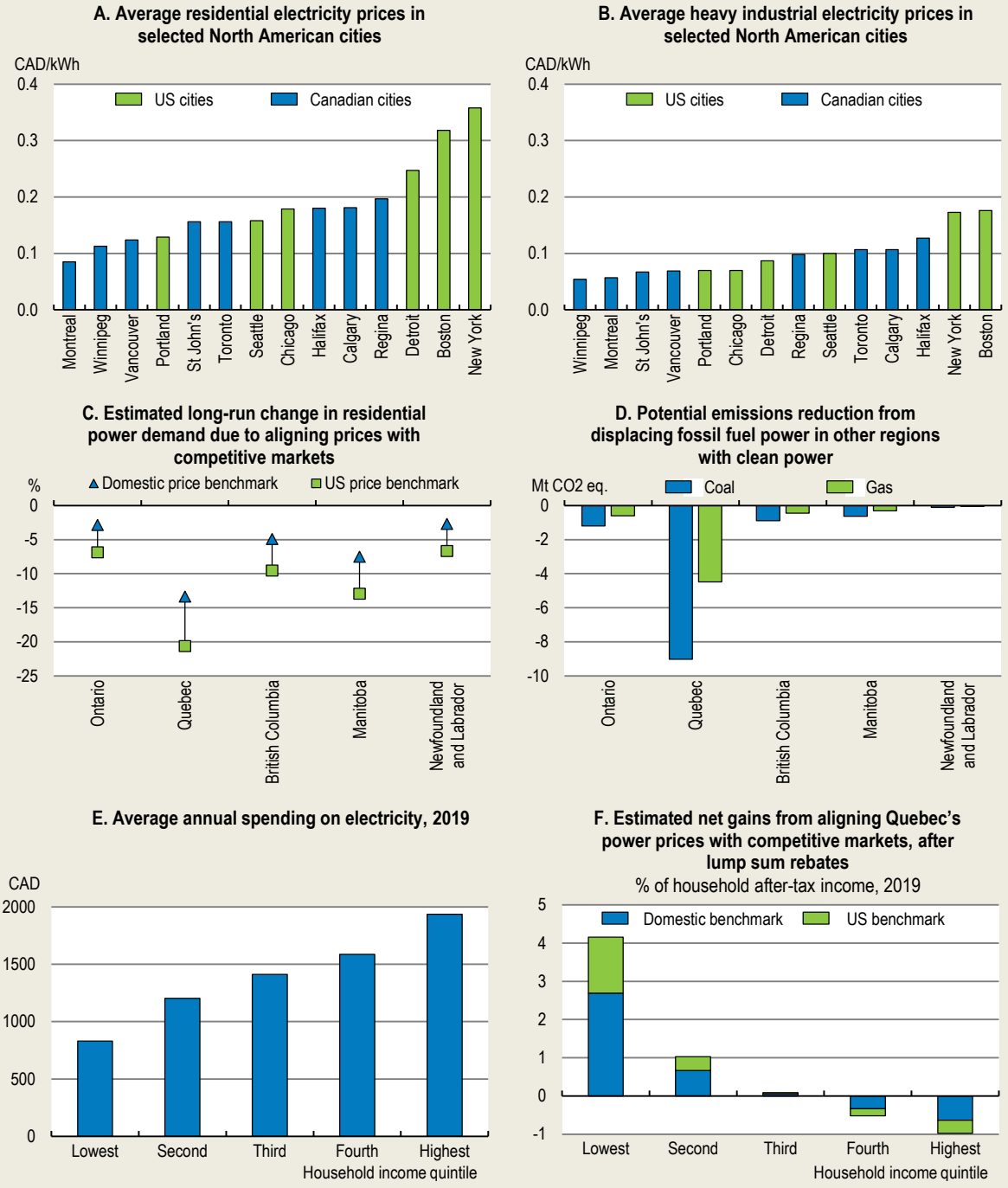
Box 6. Illustrative estimates of power pricing reform on residential electricity demand

Subsidies implicit in Canada's regulated electricity prices encourage heavy power use in homes and businesses (Figure 11, Panels A and B) (Luu, 2016[28]). Electricity prices in Canadian provinces with regulated power markets and abundant hydroelectricity tend to be low compared with competitive markets in Canada and parts of the United States. Residential customers, in particular, face lower power costs than in other jurisdictions. This has some benefits. Low power prices discourage use of natural gas heating – where it is an option – and incentivise electric-vehicle take-up. But there are important drawbacks too. Cheap electricity can lead to over-consumption of energy and distort resource allocations to favour energy-intensive activity. High-income households benefit the most. Pooling power from regulated markets with competitive electricity markets in the region could enable a transition to market-based electricity pricing. Aligning prices with Alberta's competitive wholesale market would increase utility bills in many provinces. Larger changes would result if local prices were to converge on those in higher-priced US markets (Pineau, 2008[36]).

Higher electricity prices would encourage more efficient electricity use. Using conservative estimates of long-run demand responses to electricity prices and similar assumptions to those in Pineau (2008[36]), Figure 11, Panel C shows stylised estimates of power consumption declines that might result from provinces moving towards market-based pricing for residential customers. Estimated demand effects are largest in provinces that currently have very low local prices, such as Quebec. Energy-efficiency improvements could free up clean electricity for other uses, including exports. This could reduce generation of higher-cost fossil fuel power in the region, lowering greenhouse gas emissions (Figure 11, Panel D). Environmental benefits could be offset by a slower local transition to low-carbon technologies such as electric vehicles. Such effects would, however, be mitigated by planned rises in Canada's carbon price floor and electric-vehicle support measures.

Higher revenues from market-based pricing of electricity could be returned directly to households as lump-sum transfers (Pineau, 2008[36]), similar to federal redistribution of carbon pricing revenues in backstop provinces. Rebate values would ideally be unrelated to a household's power consumption. This would generally benefit those on lower incomes, who spend less on power than well-off households (Figure 11, Panel E). People able to use less electricity would benefit from such a policy: their bills would shrink while their rebates would be unaffected. Figure 11, Panel F illustrates the potential net income effects of market-based power pricing, accounting for rebates.

Figure 11. Power pricing reform could encourage energy saving and reduce emissions



Note: Panel A and B: The charts show average prices, including taxes, on 1 April 2021. "Heavy industrial" refers to large power customers with power demand of 50 000 kW and consumption of 30 600 000 kWh. Panel C: The price in Calgary is used as the domestic benchmark price for all provinces. The US benchmark is Detroit. Transmission costs are not taken into account and would in practice sustain some price differences between markets. Panel D: The chart shows the direct effect on greenhouse gas emissions of reducing coal or natural gas electricity by a quantity equal to the clean electricity saved through pricing reforms. Emissions reductions would be greatest where clean electricity displaces coal generation in importing markets either in Canada or the United States. Panel E: The chart shows average before-tax yearly spending on electricity for a household's principal accommodation. Panel F: The chart presents estimates of the net effect on households in Quebec of higher power bills, assuming households are compensated with rebates reflecting increased returns to Crown assets. Demand is assumed to be inflexible to price changes initially.

Source: Hydro Quebec (2021[37]); CER, Canada's Energy Future 2021; Canada's National Inventory Report 2021; and Statistics Canada.

StatLink 2 https://stat.link/ad32m6

Box 7. Case studies in production pooling: the United States and northern Europe

Common wholesale markets for electricity exist in other OECD countries. In the United States, utilities from New Jersey and Pennsylvania formed a common power pool in 1927 called "PJM". In northern Europe, Norway joined Sweden and subsequently other Nordic countries in a wholesale electricity market launched in the early 1990s. Both projects developed competitive spot markets for electricity, with wholesale prices determined in large part by marginal cost – the price of the last unit of electricity needed to align supply and demand.

For low-cost generators, entering such markets can bring higher revenues than in closed local markets. Both suppliers and customers, however, contend with greater price volatility than in regulated electricity markets. This can be mitigated by financial instruments or addressed with direct intervention by market operators. In PJM, participants use forward contracts and bilateral transactions that reduce purchasers' exposure to volatile spot prices. Financial contracts are similarly used for price hedging and risk management in Nord Pool.

Governments can take additional measures to shield households from hardship when electricity prices are very high. Norway's central government used temporary price subsidies to reduce cost pressure on households in 2022 during the energy crisis.

Source: PJM (2022[38]), Nord Pool (2022[39]).

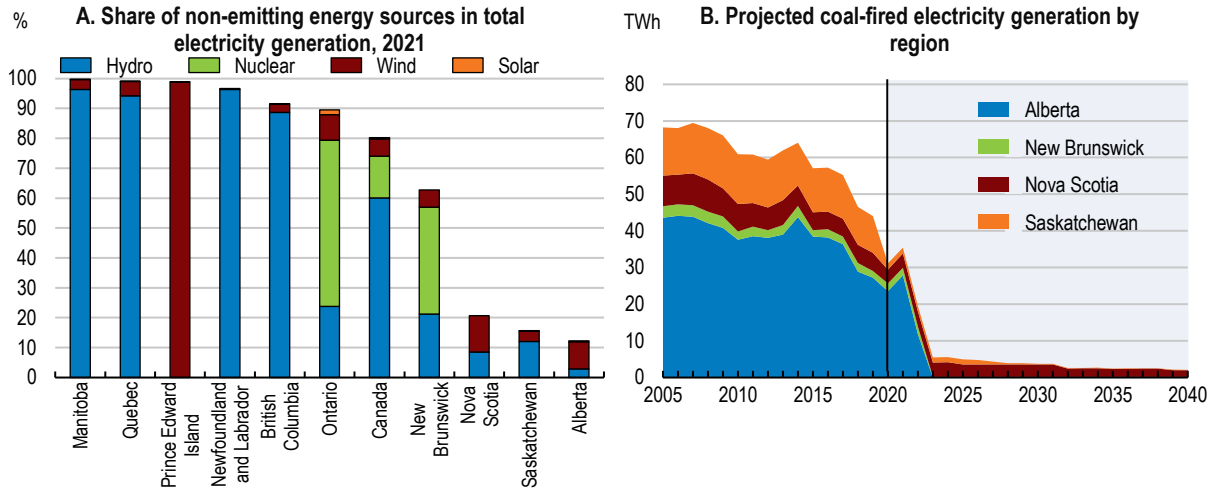
Without significant reform to provincial power market regulation, additional policies are needed to accelerate decarbonisation of electricity in Canada. Reflecting disparities in their access to renewable energy sources, some provinces have more work to do than others to retire emission-intensive power stations. Regions including Saskatchewan and Nova Scotia still rely heavily on fossil fuel-generated electricity (Figure 12). Federal regulations require coal power to be eliminated by 2030. Natural gas will remain in grids for considerably longer. Alberta and Saskatchewan are among provinces looking to replace outgoing coal with new gas plants. Once added to the grid, such facilities will put a floor under emissions reductions or later require expensive retrofitting with carbon capture technology.

To strengthen signals that Canada's future grid must be green, the federal government proposes to introduce clean electricity regulations. The new regulations would force the phase-out of unabated fossil fuel electricity by 2035. With carbon pricing signals likely impeded by regulation in some provincial power markets, a clean electricity standard can play a useful role in speeding up grid decarbonisation (Shahnazari et al., 2017[40]). Use of tradable standards can improve the measure's efficiency. To ensure clean energy capacity is developed in locations where returns are greatest, the regulations should also be designed to be neutral both as to clean energy sources and with respect to geography. Experiences of related policies in US jurisdictions suggest that geographical restrictions can encourage local generation of clean electricity but also increase power costs (Carley et al., 2018[41]).

Technology support will continue alongside tougher federal regulations. Natural Resources Canada administers a range of federal grants designed to improve the cost competitiveness of low-carbon energy generation. In 2022 the federal government launched a new initiative offering investors a refundable tax credit of up to 30% of capital expenditure on solar photovoltaic and other energy generation systems.

Governments should also ensure adequate support to workers and communities hard-hit by the phase-out of coal power. Past experiences in Canada and other countries suggest this is best done with a combination of labour market policies, place-based investments, and measures to remove obstacles to geographical mobility (Box 8).

Figure 12. Access to clean electricity varies across Canada



Note: Panel A: "Low-carbon" electricity includes hydro, nuclear, wind and solar electricity generation; Panel B: Shaded area indicates projections. Projections start in 2020 based on the CER's primary "evolving policies" scenario. The scenario assumes action to reduce the GHG intensity of energy continues at a pace similar to recent history.
Source: Statistics Canada; and Canada Energy Regulator (2021[42]).

StatLink 2 https://stat.link/tflzcg

Box 8. Supporting workers affected by the end of coal power: Alberta, Germany and Greece

Accelerated phase-out of coal power can have long-lasting economic and social impacts on affected workers and communities. Provinces yet to phase out coal power – including Saskatchewan, Nova Scotia and New Brunswick – can learn from the experiences of other Canadian regions and other OECD countries. Experiences in Alberta and Germany reveal that retraining, employer-assisted re-employment, and re-location assistance can mitigate harm from an industry's rapid decline. Public investment, including in green energy projects, can separately spur activity and job creation in hard-hit regions while helping to replace outgoing fossil fuel power. This is a large part of Greece's strategy for supporting workers and communities affected by the phase-out of lignite mining.

Alberta

Planned retirement of Alberta's remaining coal power facilities was brought forward after a change in government in 2015. On top of compensation for companies affected by forced plant closures, the government sponsored transition programmes to help workers. Assistance included grants for those temporarily out of work or close to retirement, re-imbursement of moving expenses, subsidies for retraining, and access to career consultants. Adjustment committees, involving companies and unions, supported individual displaced workers, including with re-employment services. Job losses and broader economic impacts on affected communities were offset in part by employment opportunities in new power and transport infrastructure projects.

Germany

Germany's withdrawal of remaining coal industry subsidies in 2007 forced mines still operating in the country's Ruhr region to close. From a workforce of 24 000, less than 4 000 remained in 2018 when the last mines closed. Coal's exit from the region was jointly managed by coal companies, trade unions and governments. Employer-supported job transfers and government-sponsored retraining assisted coal workers to find new employment. Subsidised early retirement aided those close to pension age. Workers moving to new jobs frequently saw their earnings decline, but sharp rises in unemployment were avoided.

Greece

The Government of Greece plans to end generation of electricity from burning brown coal (lignite) by 2028. This will cause significant job losses in Western Macedonia, where Greece's lignite mining is concentrated. Many of the workers displaced from employment in mining and related industries are expected to pick up jobs created by government investment in the region. Initiatives included in Greece's *Just Transition Development Plan* will see capital expenditure in natural gas and renewable energy generation as well as investment in tourism and other industries. Regional policies also support existing businesses and individuals affected by the lignite phase out.

Source: Jackson and Hussey (2019[43]), World Resources Institute (2021[44]), OECD (2023[45]).

Regulatory hurdles to new energy projects can reduce returns to investing in clean power. Progress has been made in some jurisdictions to address time-consuming approval processes. Newfoundland and Labrador lifted a ban on offshore wind farms in 2022. Ontario, Alberta and British Columbia have taken steps to speed up permitting, including by coordinating approval processes at the provincial level (see, for example, Government of Ontario (2019[46])).

There remain important hurdles that can slow the expansion of low-carbon electricity generation. Some provinces maintain effective bans on offshore wind projects (Government of Ontario, 2019[46]). Reporting and consulting requirements add to the cost of applications, which are large for projects requiring comprehensive impact assessments. Mandatory consultations can involve many stakeholders – including local landowners, municipalities and Indigenous communities. To go ahead, projects sometimes need approvals from municipal, provincial and federal authorities. Outcomes of review processes are subject to broad ministerial discretion and thus can be highly uncertain. This could affect the cost of finance for clean energy developments, increasing the returns needed to make projects viable.

Governments should work to reduce unnecessary regulatory and administrative barriers to renewable energy investment. Provincial bans on offshore wind should be avoided. The federal government could take a more active role in setting guidelines or model rules for sub-national jurisdictions to adopt. This might include recommended threshold project sizes for mandatory impact assessments. Provinces should also be encouraged to pre-approve land suitable for renewable energy projects. Applications with respect to such sites could be subject to simplified review processes, as has been proposed for European countries (European Commission, 2022[47]). Federal agencies could assist provinces and municipalities with standardised data to identify land with low environmental risk.

Policies to moderate electricity demand

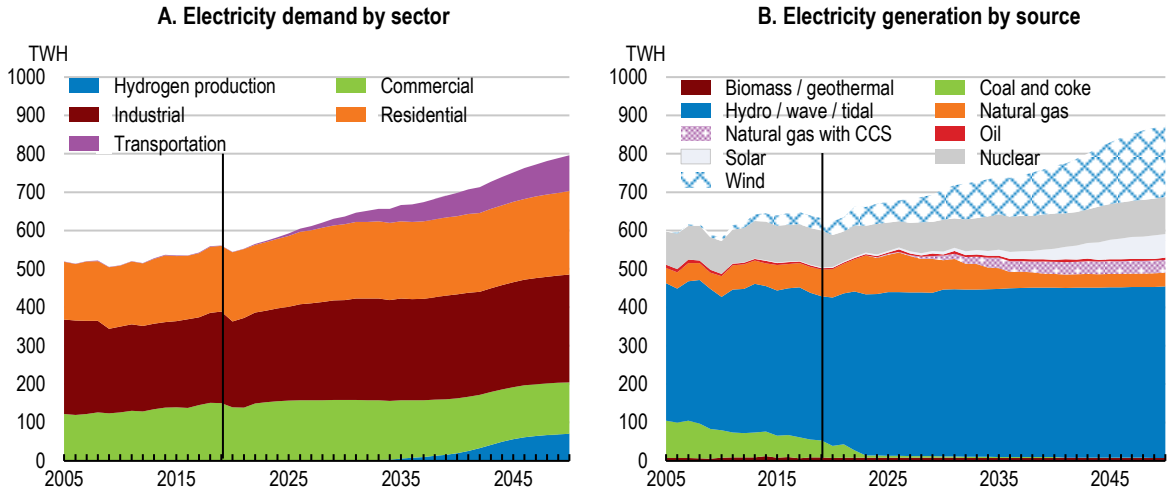
The green transition will increase demand for electricity. Propelled in part by rising carbon rates on competing fossil fuel energy sources, power consumption is projected to grow with electrification of industry, transport and buildings (Figure 13). This will compound pressure from growth in Canada's population and economy. By some estimates, electricity demand in 2050 could be up to 2.1 times larger than today, requiring 2.2 to 3.4 times current generation capacity (Dion et al., 2022[48]).

Reducing electricity demand in peak periods will be important for electricity-system efficiency and to limit required additions to the power supply. Peaks in power consumption influence both the minimum generation capacity required to satisfy local demand and also intra-daily calls on higher-cost carbon-intensive electricity generation.

Complementing investments in storage, greater use of demand management policies such as time-variant pricing will be important to handle new pressures. Many provinces offer time-of-use pricing for industrial customers (33% of electricity demand in 2020) but only Ontario does so on a standard basis for households (IEA, 2022[26]). Making time-of-use pricing a default option for residential power customers would help shift power consumption to off-peak periods. This will become more important as take-up of electric vehicles increases calls on the grid. Greater use of smart meters and time-of-use pricing, together with good communication of new pricing policies, would encourage users to track the cost and quantity of their power consumption. Higher prices in peak periods – ideally aligned with the marginal cost of providing power – can reduce maximum total power consumption and required additions to generation capacity. This could complement other policies aimed at reducing overall energy use, such as carbon pricing, energy-efficiency regulations for appliances and buildings, and incentives for retrofitting buildings (discussed below).

Figure 13. Electricity demand is projected to increase

Projected electricity demand and generation



Note: The graphs show projections from the Canada Energy Regulator's *Energy Future 2021* report. Estimates are from the report's central scenario, which assumes policies to reduce GHG emissions from energy tighten in line with recent trends, both in Canada and in other countries.
Source: Canada Energy Regulator (2021[42]).

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Box 9. Mitigation and adaptation priorities in Indigenous and northern communities in Canada

Reducing reliance on diesel and moving to clean energy solutions

Over 250 remote communities in Canada are not connected to the North American electricity grid. Many of these communities are in the country's northern territories. Most are Indigenous. Canada's off-grid communities rely mainly on diesel generators for energy. Diesel generators are reliable and cheap to install. Their fuel is dense in energy and easy to store. But diesel is also expensive, subject to oil price volatility and high-emitting when burnt. While ending use of diesel is not feasible in all communities, there is scope in many areas to supplement diesel with wind or solar energy. This can reduce both ongoing costs and emissions.

Canada has a range of programmes to support clean energy projects in Indigenous, rural and remote communities with funds and training to use fuel more efficiently and develop renewable energy capacity. Funding is available for energy efficiency, capacity building, and capital projects in communities across Canada through the federal Clean Energy for Rural and Remote Communities program. The federal Northern REACHE programme funds renewable energy projects, energy-efficiency investments and capacity building in Yukon, Northwest Territories, Nunavut, Nunavik, and Nunatsiavut. Targets of federal support include retrofitting of lighting in government buildings, upgrades to reduce heat loss in low-income housing, installation of heat pumps and small renewable energy systems, and community-based bioenergy projects. Such initiatives will help reduce emissions from energy use in remote communities. Separately, the Indigenous Off-Diesel Initiative, a clean energy training and funding programme, supports Indigenous-led climate solutions in remote communities that currently use fossil fuels for heat and power.

Preparing remote communities in Canada's north for changing climates

Climates are changing rapidly in Canada's north, with temperatures increasing at three times the global average rate since 1948. Warmer weather is impacting biodiversity as well as traditional sources of food and ways of life in Indigenous communities in Canada's northern territories. Many settlements are vulnerable to rising sea levels and increased risk of flooding. Shorter ice cover seasons are affecting transport on ice roads in warmer winters, which is crucial for isolated regions with limited access to permanent roads. Highways and airport runways built on frozen earth are already being damaged as permafrost thaws. This can affect communities' access to food, fuel, building materials and essential services. Homes and energy infrastructure are also vulnerable when permafrost thaws and cracks.

Recognising risks to health, incomes and wellbeing, governments are working with Indigenous and remote communities to identify risks and implement adaptation plans. Efforts to date by the federal and sub-national governments include modifying transport infrastructure standards for resilience in warmer winters, tracking road surface temperature, and reinforcing damaged highways. Federal initiatives such as the Climate Change Preparedness in the North programme have supported development of new land management rules, measures to prevent coastal erosion, and flood-proof standards for flood-affected areas. Indigenous knowledge can also contribute to effective adaptation, drawing on experience of coping with trends and variability in local environmental conditions (OECD, 2023[49]). The Government of Canada recognises that supporting Indigenous climate leadership, and collaboration on adaptation, is important for self-determination.

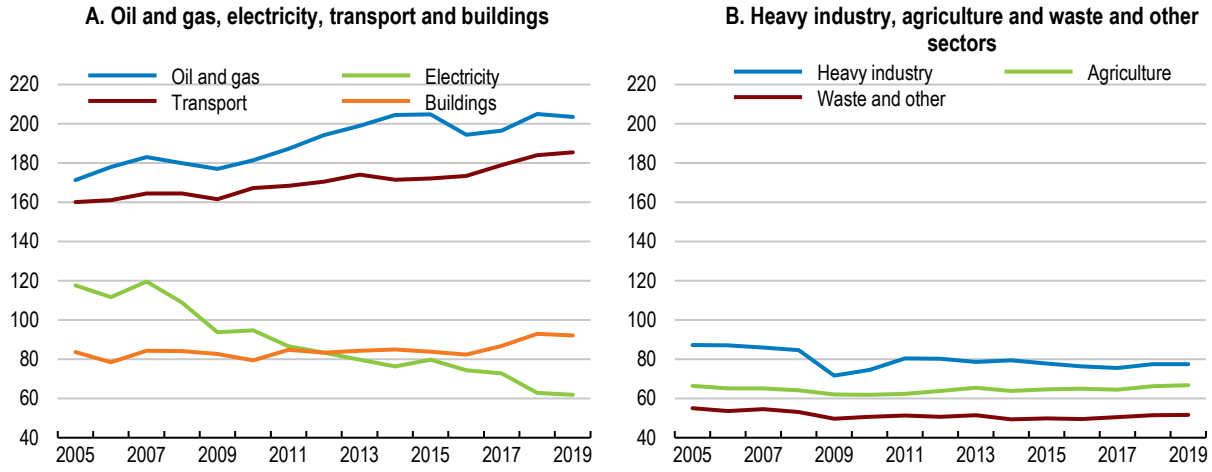
Sources: IEA (2022[26]), ECCC (2022[50]), Indigenous Climate Hub (2022[51]), Canada Energy Regulator (2018[52]), CIRNAC (2022[53]).

Reducing emissions from oil and gas production

Emissions from oil and gas extraction accounted for 27% of Canada's greenhouse gas emissions in 2020, more than any other sector (Figure 14). Oil sands production – the sector's most carbon-intensive activity – increased with higher crude oil prices from the early 2000s, driving up emissions. Increased oil sands output more than offset the GHG impact of reductions in the emission-intensity of oil and gas products (Box 10).

Figure 14. Oil and gas emissions have increased

GHG emissions by sector, Mt CO_2 equivalent



Source: Environment and Climate Change Canada (2022[2]).

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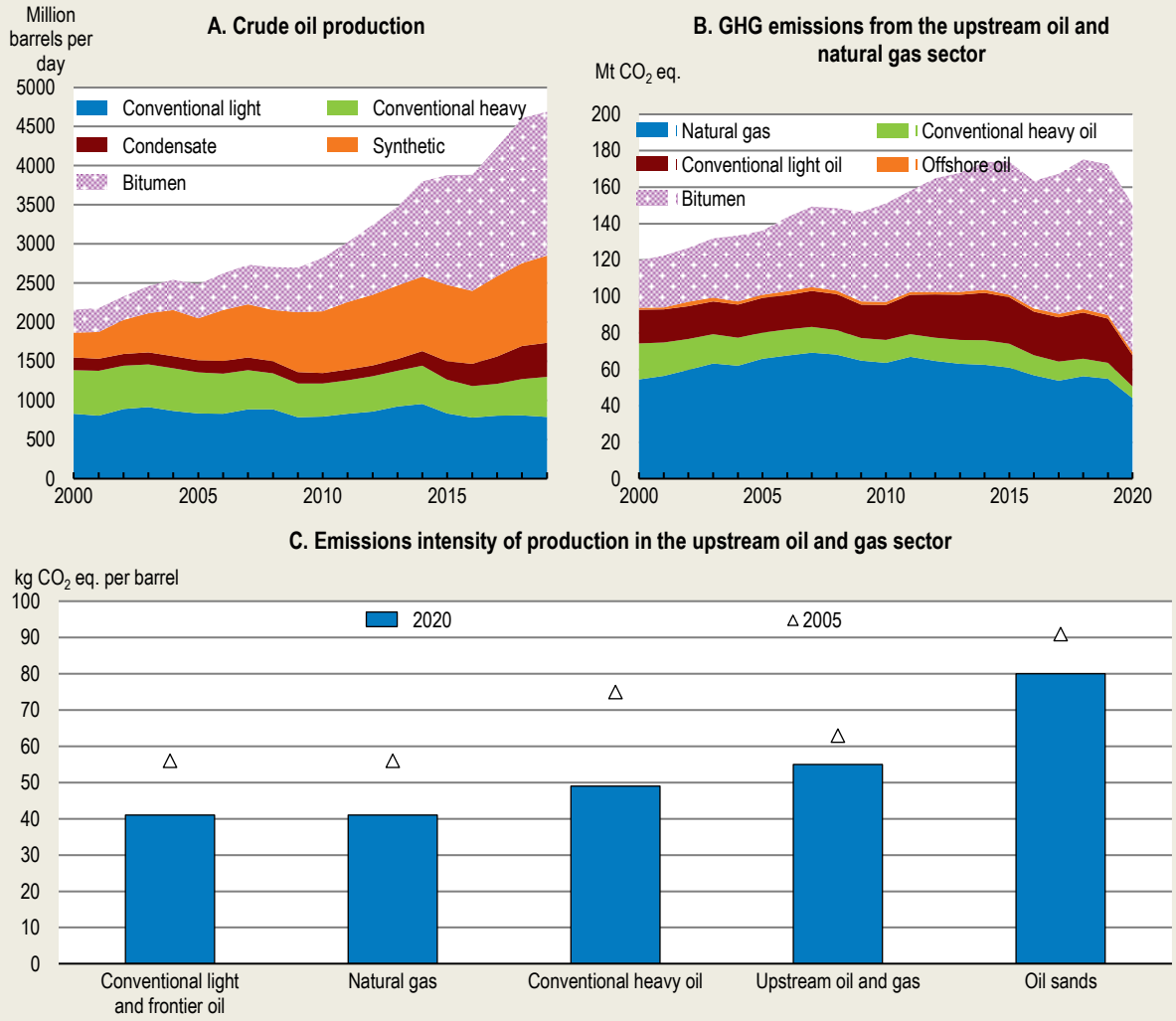
Box 10. Sources of oil and gas sector emissions in Canada

Large emission reductions are needed in oil and gas extraction. Oil sands extraction and upgrading generates significant energy-use emissions (Figure 15), accounting for just under half of all greenhouse gas emissions from oil and gas production in Canada. Natural gas is burned in large volumes to generate steam or hot water needed to separate bitumen from underground oil sands deposits (called *in-situ* mining). Oil sands can also be dug directly out of the ground. While typically less polluting than in-situ mining, "surface mining" is also capital and energy-intensive and contributes to fuel use emissions. Methane emissions from leaks as well as intentional venting and flaring from conventional oil and gas production are also significant (ECCC, 2022[2]). In contrast, petroleum refining and distribution are responsible for a small share of the sector's total emissions.

Figure 15. Increased oil sands (bitumen) production has driven up oil and gas emissions



Note: Panel B: Bitumen includes emissions from oil sands extraction and upgrading. Natural gas includes emissions from production and processing. Panel C: The chart shows estimated average emission intensity per barrel for selected upstream oil and gas subsectors.
Source: Canada Energy Regulator (2022[54]); Environment and Climate Change Canada (2022[2]).

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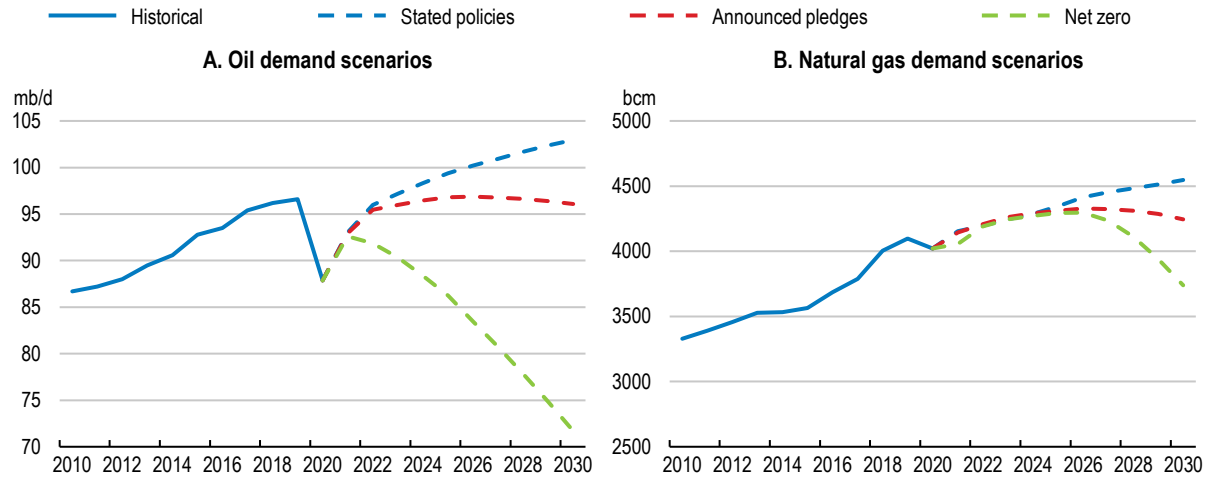
Modelling for Canada's 2030 Emissions Reduction Plan factors in a 40% fall in oil and gas sector emissions from 2019 levels by the end of this decade. The federal government aims to achieve large reductions in the sector's greenhouse gas emissions without imperilling the global competitiveness of a key industry (ECCC, 2022[55]). Regulations, green investment support and market-based policies must be used together effectively to ensure producers have strong incentives to invest in decarbonisation without inducing the relocation of oil and gas operations to jurisdictions with weaker climate policies. Effective use of highly efficient policies like carbon pricing can reduce the need for more distortive and fiscally costly technology support.

Carbon pricing and regulations will help decarbonise oil and gas production as impetus for green transition policies strengthens globally. The long-term prospects of Canada's oil and gas sector are tied to world demand for fossil fuels. Based on announced commitments, the IEA projects that demand for oil and gas

could start declining before the end of the current decade (Figure 16). Canada's Energy Regulator projects that the country's crude oil production could start falling next decade (Canada Energy Regulator, 2021[42]) if global demand slows and prices decline. Higher carbon prices levied on an increasing share of their emissions will have a large impact on oil and gas producers' costs. Recent changes to royalty systems in some provinces separately affect returns to oil and gas projects. In 2022 British Columbia introduced a new royalty system, eliminating the province's largest implicit fossil fuel subsidy – the Deep Well Royalty Program (Government of British Columbia, 2022[56]). The new system also increased the minimum royalty rate, promising to capture a larger share of natural resource rents. Other policies, such as the federal Impact Assessment Act, are likely to directly limit scope for new emission-intensive oil and gas projects. The Impact Assessment Act outlines a process for evaluating the environmental effects of designated major developments, including surface mining oil sands projects. The Act empowers the federal government to block high-emission projects. Such policies could help limit accumulation of assets at risk of becoming stranded in a net-zero emission world.

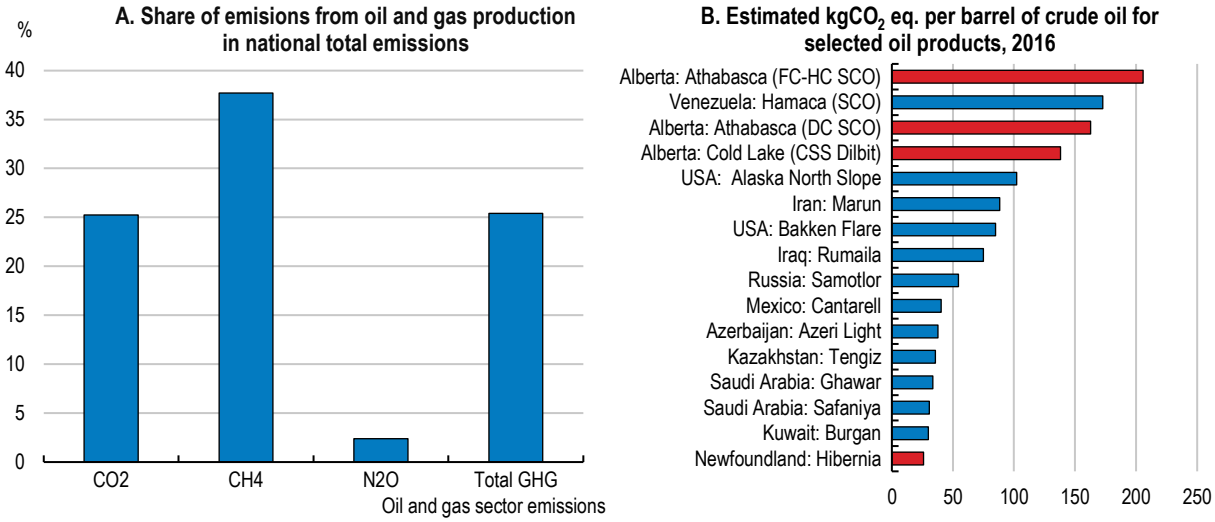
Figure 16. World demand for fossil fuels could peak in the coming years



Source: IEA (2021[57]).

Canadian oil sands production may be particularly vulnerable to the effects of green transition policies in other countries. Operating costs are high relative to those of many large foreign crude oil producers. Major oil producers in the Middle East can produce oil with less upstream emissions and at lesser expense than Canadian oil sands producers (Figure 17). Higher abatement costs could see Canada's biggest-polluting operations drop out of world supply sooner than competing foreign facilities, particularly if there are sustained falls in oil prices (Mercure et al., 2021[58]).

Figure 17. A large share of Canada's GHG emissions are from oil and gas production



Note: Panel A: Oil and gas production includes upstream, transmission and downstream activities. Panel B: The graph shows major world oil products, each comprising a minimum 500 000 barrels per day, as well as large oil sands fields from Canada and Venezuela and Newfoundland's Hibernia offshore oil field. Canadian oil products are shown in red. Athabasca and Cold Lake are major oil sands deposits in Alberta. "DC SCO", "FC-HC SCO", "CSS Dilbit" and "SAGD Dilbit" are all extra-heavy, high-sulphur bitumen oil products. Estimates are presented for emissions from "Upstream" extraction, processing and transportation to refineries. Emission intensity varies across Canada's oil sands operations. Use of paraffinic froth treatment processes can, for example, lower emissions from oil-sands mining.
Source: ECCC (2022[2]); Carnegie Endowment Oil-Climate Index.

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Reducing methane emissions in the oil and gas sector

The oil and gas sector contributes over a third of Canada's methane emissions. Better detection and repair of leaks and eliminating routine venting and flaring practices can reduce methane emissions from conventional oil and gas production. Relatively low-cost investments – including maintenance, replacement and upgrading of equipment – can reduce fugitive emissions and limit methane emitted by flaring and venting (McKinsey & Company, 2020[59]). By some estimates, reducing methane releases can do more in the near term than any other measure to decrease greenhouse gas emissions from oil and gas production (Gorski and McKenzie, 2022[60]).

Backing up a pledge to contribute to global methane reductions, Canada's federal government aims to reduce methane emissions from oil and gas production by 40 to 45% from 2012 levels by 2025. The government has announced that by 2030 it will require oil and gas-sector methane emissions reductions of at least 75% from the 2012 benchmark. A 2021 review found that Canada is on track to meet the interim objective. At present, regulations are the main instrument used in Canada to reduce methane emissions. Federal rules set limits on venting – controlled processes to dispose of gases by releasing them into the atmosphere (ECCC, 2021[61]). These apply to upstream facilities that extract, process and transport natural gas. Provinces have analogous rules in place. Recently concluded equivalency agreements confirmed that the provincial rules are at least as strict as the federal regulations. Canada has announced a regulatory framework for reducing oil and gas methane emissions to achieve the 2030 target. Tighter federal methane regulations are expected to be introduced in 2023.

Pricing methane emissions could reduce reliance on regulations and encourage low-cost abatement action. Improved methods for estimating or measuring methane emissions would make it easier to impose a charge on such emissions in carbon pricing systems. This could reduce reliance on more heavy-handed

regulations. While some regulation will remain important to prevent environmentally harmful practices, overly prescriptive production standards can impose higher costs on businesses than market-based policy instruments for encouraging abatement. Work is underway to improve tracking of methane emissions, which have been underestimated in the past (ECCC, 2021[61]). Canada has made significant progress in recent years, becoming a leader in efforts to detect and mitigate methane emissions. It could continue to draw on experiences in other countries, including Norway's efforts to improve measurement and estimation of methane emitted from offshore oil and gas installations (Box 11).

Box 11. Improving methane emission measurement – a case study of Norway

Norway introduced a ban on routine (non-emergency) flaring in 1971 and in 1991 a tax on emissions was introduced. The remaining methane emissions from upstream oil and gas extraction make up the bulk of Norway's methane emissions. In 2016, Norway completed a major project to assess methane emission sources from all of its permanent offshore oil and gas facilities as well as methods for quantifying emissions. Following the project, Norway revised its methods for estimating methane emissions.

Facilities equipped with flow meters directly measure methane emitted from emergency venting and flaring. This covers around two thirds of inventoried methane emissions. The other third are estimated using regulator-prescribed quantification models. Norway's revised bottom-up emission estimates were found to be lower than previous estimates. Aerial measurements corroborated this finding.

High-quality quantification methods allow Norway to continuously improve taxation of methane emitted from emergency venting, flaring and leaks from oil and gas operations on the Norwegian Continental Shelf. This encourages producers to identify and implement low-cost methods for reducing their emissions.

Advances in tracking methane in Norway were facilitated in part by the relatively small number of large offshore oil and gas operations responsible for the bulk of the sector's methane emissions. Most methane from Canada's oil and gas sector is, in contrast, emitted from onshore activities, where there are a larger number of operations. Segments of Canada's oil and gas sector could still emulate aspects of Norway's approach to improve estimates of methane emitted from upstream oil and gas facilities (IEA, 2020[62]). Pricing methane emissions could reduce the role of less-efficient regulations and facility-specific emission caps.

Source: IEA (2020[62]).

Reducing fuel combustion emissions in the oil and gas sector

Fuel combustion is a major source of greenhouse gas emissions in upstream oil and gas production. Over half of the sector's total emissions (54% in 2020) come from oil sands production, largely from burning natural gas. Reducing fuel combustion emissions will require cleaner energy, less fuel-intensive production, and better systems for capturing carbon. The main policy tools used to accelerate such changes in Canada are carbon pricing and support for carbon capture investment.

Proposals for new carbon pricing systems for the oil and gas industry

Oil and gas producers' fuel-use emissions are covered by carbon pricing schemes, which encourage efficient energy use and switching to lower-carbon fuels. Emissions benchmarks in baseline-and-credit schemes determine the share of emissions producers pay a charge on, and thus also their average carbon costs. While the possibility of earning performance credits maintains an abatement incentive, past emissions benchmarks have sometimes been set at levels too high to drive deep decarbonisation. For

instance, Alberta's surface-mining oil sand facilities paid less in charges on their carbon emissions in 2020 than they received in credits for beating their emissions benchmarks (Alberta Environment and Parks, 2021[63]). As a result, high-emitting producers profited from a carbon pricing framework meant to encourage greener production by raising carbon costs.

The federal government is weighing up new measures to address pitfalls in the treatment of oil and gas producers in provincial carbon pricing systems (ECCC, 2022[55]). Two alternative options are being considered:

- **A sector-specific carbon price***.* Federal regulations would prescribe strict emissions intensity standards for upstream oil and gas facilities. If necessary to meet a sector-wide emission reduction target, oil and gas facilities would pay a higher carbon price than facilities in other industries. Credit trade would be possible within the oil and gas sector but could be restricted outside the sector.
- **Cap-and-trade scheme***.* A new cap-and-trade scheme would apply only to the oil and gas sector. A declining cap would deliver GHG reductions consistent with Canada's path to net-zero emissions by 2050. Allowances in the scheme could be traded with other participants but not with firms participating in other emissions pricing schemes.

Both options would ensure the oil and gas sector contributes directly to emissions reductions, rather than purchasing credits earned in other sectors. However, in constraining permit trade and levying different carbon prices on different emitters, neither proposal would promote efficient abatement, which would require least-cost reductions to be pursued across the economy as opposed to within specific sectors. Both schemes could also suffer from elevated volatility in allowance prices caused by global commodity shocks, which could influence public acceptance of new carbon pricing instruments. Increased uncertainty around future abatement costs could also complicate decisions surrounding major green investments. It would be better to improve current emissions trading systems (discussed above) than risk fracturing a sometimes strained consensus on important climate policies.

Support for oil and gas sector carbon capture utilisation and storage investments

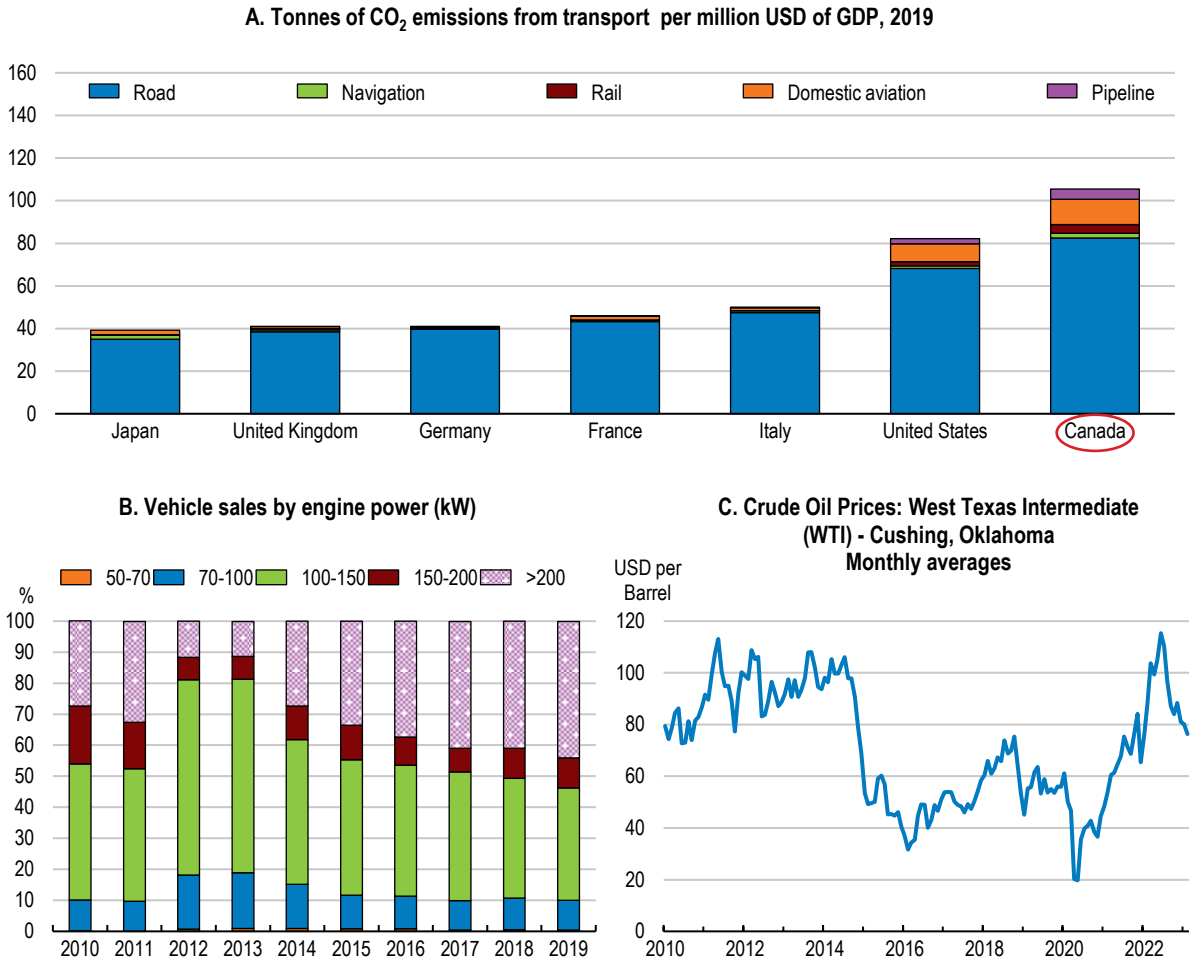
Carbon capture utilisation and storage is expected to contribute significantly to decarbonising oil sands production (ECCC, 2022[1]). Federal and provincial governments fund research, development and demonstration of CCUS technology. CCUS investments are further subsidised through carbon offset schemes, grants, provincial royalty credits, and Canada's Clean Fuel Regulations (discussed below). Aimed at accelerating CCUS take-up, these policies reduce investment risks and improve the cost competitiveness of maturing technologies. They can also lower barriers to development of local CCUS markets, avoid under-provision of green R&D, and may capture knowledge gains from using CCUS technology in oil and gas production in Canada.

It will be important to review major support programmes to check they deliver intended results at projected costs. Current incentives offer larger rewards for CCUS-based abatement than for other mitigation actions. As well as the usual carbon pricing incentive in large emitter schemes (worth CAD 65 per tonne in 2023), abatement through oil-and-gas sector CCUS can earn up to CAD 300 per tonne (indexed to inflation from 2022) under new Clean Fuel Regulations. Such benefits add to support from a proposed federal investment tax credit for expenditure on CCUS technology, costed at around CAD 8 billion between now and 2030. Incentives should be scaled back over time as CCUS markets mature and cost competitiveness improves. The proposed federal investment tax credit is appropriately designed such that its generosity declines after 2030. This will limit risk of carbon credit oversupply, which could weaken mitigation incentives in other sectors. Alberta is also reviewing the way its offset scheme rewards abatement through CCUS. In 2022, CCUS operations could earn one offset for capturing a tonne of carbon and a second offset for sequestering the same emissions (Government of Alberta, 2022[14]). To preserve carbon pricing signals, such policies should be revised for consistency with updated federal requirements that offsets reward "additional" abatement.

Policies to reduce road transport emissions

Transport accounted for 25% of Canada's greenhouse gas emissions in 2020. In most provinces it is the biggest source of carbon pollution. The bulk (over 80%) comes from road transport (Figure 18, Panel A). Both passenger vehicles and heavy-duty trucks have contributed to increased emissions from burning petroleum and diesel. This occurred with increased driving and an expanding stock of larger, less fuel-efficient vehicles including sport utility vehicles (Figure 18, Panel B) (Balyk, Livingston and Hastings-Simon, 2021[64]). Road transport emissions rose despite higher carbon costs and tighter vehicle standards. Rapid progress is needed to reduce tailpipe emissions from trucks and cars, particularly given greater obstacles to decarbonising air and marine transport (Box 12). This will require a combined policy focus on reducing both the emission-intensity of driving and vehicle kilometres driven. Beyond support for electric vehicle take-up, measures to improve access to active transport and public transport, and reduce car dependency, can spur deep emissions reductions.

Figure 18. Road transport emissions are significant



Note: Panel A: Emissions from international transport and international navigation are excluded. Pipeline refers to long-distance transport of liquids or gas through a system of pipes. Panel B: Engine power is expressed in average kilowatts (kW).
Source: OECD Transport database; IEA (2021[65]); and Refinitiv Datastream.

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Box 12. The longer-term ambition of decarbonising air and marine transport

Aviation and marine transport together generated 6% of Canada's transport emissions in 2019. Abatement is challenging in both sectors (ITF, 2021[66]). Planes and ships use large amounts of carbon-intensive fuel and generate emissions that can be tricky to assign between jurisdictions. Improvements in propulsion technologies and low-carbon fuels are needed to make green transport commercially viable across different modes of air and marine transport. Governments can, however, put in place policies to encourage operators to use energy more efficiently and take up lower-carbon technologies and fuels.

Canada is considering working with international partners on goals and measures to reduce emissions from international aviation and shipping (ECCC, 2022[1]) – neither sector is explicitly mentioned in the Paris Agreement. Tightening fuel or technology standards would require international cooperation. Regulatory cooperation between provinces and the federal government could separately enable more widespread pricing of carbon emissions from domestic flights in Canada. Other jurisdictions have managed to achieve equivalent outcomes: aviation emissions have been included in the EU Emissions Trading System since 2012 for flights within the European Economic Area (ITF, 2021[67]).

Increased taxation of fuels used in aviation and marine transport (Teusch and Ribansky, 2021[68]) could be pursued alongside efforts to stimulate the development and take-up of low-emission technologies and fuels. Norway is among the OECD countries with aims of significantly reducing emissions from domestic air and sea transport. Working with airlines, Norway's airport operator Avinor aims to electrify all domestic flights by 2040 (ITF, 2021[67]). Nordic countries have also used public procurement and pilot projects to accelerate electrification of short-range marine transport, as well as test out liquid hydrogen and other low-carbon technologies (ITF, 2020[69]).

Source: ITF (2021[66]), ECCC (2022[1]), ITF (2021[67]), ITF (2020[69])

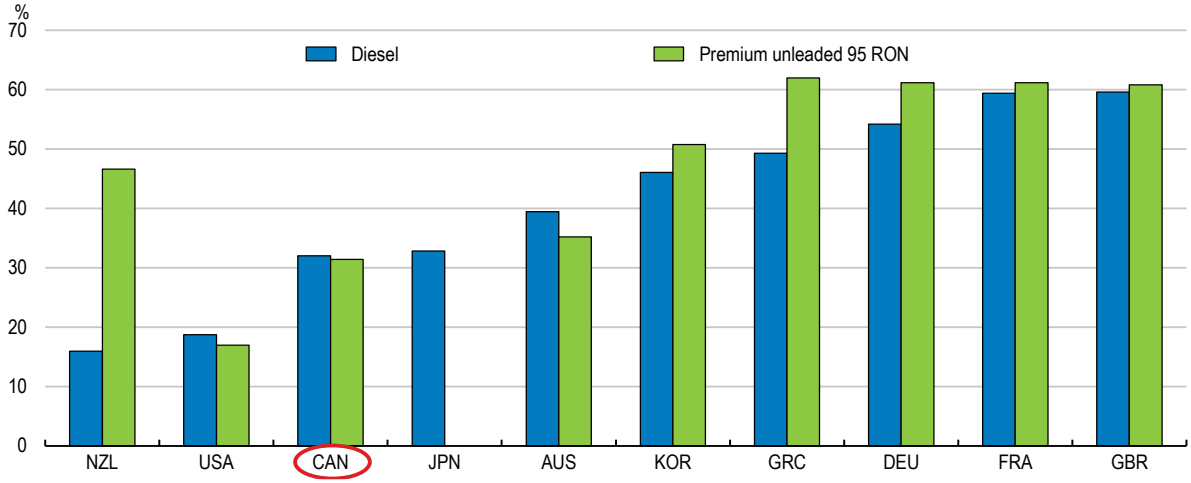
Decarbonising passenger transport

Passenger vehicles are responsible for roughly 60% of road transport emissions. After declining during the COVID-19 pandemic, passenger vehicle emissions are expected to have increased in 2022 notwithstanding high petroleum prices during the energy crisis. Car ownership rates in Canada are high. Motor vehicles tend to be less fuel efficient and more emissions-intensive than in other countries (Canada Energy Regulator, 2019[70]). The reasons for relatively heavy reliance on cars relate to Canada's geography as well as policy. Large distances between cities in a sparsely populated country encourage driving and reduce the profitability of intercity bus and rail services. Sprawling towns, sometimes with limited public transport accessibility, similarly add to the appeal of private vehicle ownership, as do relatively low taxes on fuel and limited use of road user charging (Figure) (OECD, 2017[71]). Compared with more compact European cities, the design of buildings and cities in Canada also often facilitates use of large cars.

A key focus of Canadian climate plans, and analysis of Canada's transport sector, is on how to make vehicles and transport fuel greener (see, for example, Balyk, Livingston and Hastings-Simon (2021[64]), ECCC (2022[1])). Take-up of zero tailpipe-emission vehicles (battery electric vehicles and hydrogen fuel cell electric vehicles) will be important. But slow turnover in the stock of cars means conventional combustion-engine vehicles will be on the road long after a proposed federal ban on new combustion-engine car sales takes effect in 2035. Government-commissioned projections show combustion-engine vehicles comprising 60% of light-duty vehicles in 2035 and 10% of the stock in 2050 (Dunsky Energy & Climate, 2022[72]).

Figure 19. Low operating costs encourage car ownership

Fuel taxes for households as a percentage of fuel price, 2021



Source: IEA (2022), Energy prices and taxes (database).

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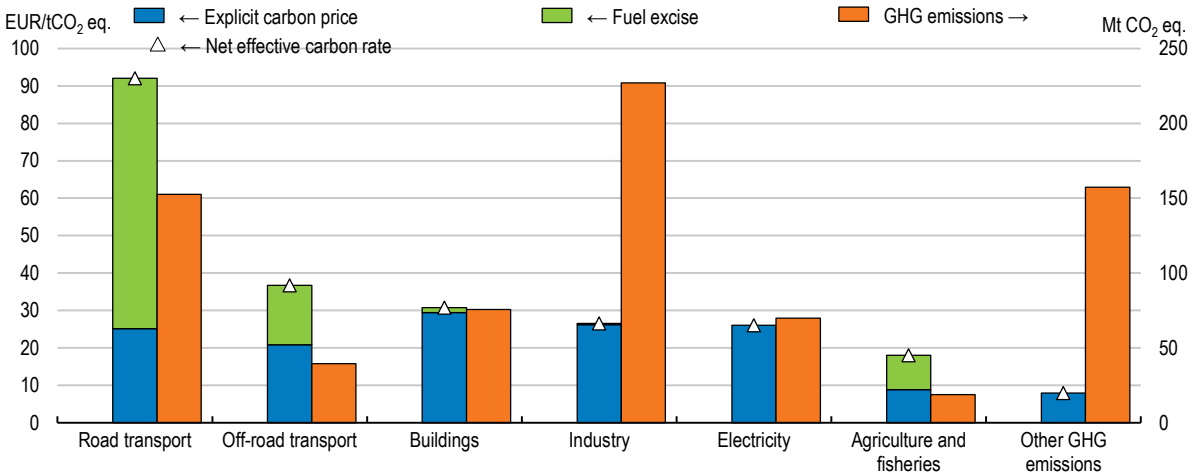
A mix of regulations and price-based policies aim to accelerate reduction of tailpipe emissions. Carbon pricing is a key instrument for discouraging intensive use of combustion engine vehicles, including second-hand cars. Higher carbon prices will increase the cost of petroleum-based fuels (Figure 20). On its own, however, carbon pricing may not spur makers of cars and transport fuels to produce cleaner products. Scale economies and other market barriers can make it hard for new entrants to compete with incumbents. For instance, petroleum refining in Canada is dominated by the same companies that extract crude oil. Incumbents have incentives to defend profits along fuel supply chains by resisting transformation of the sector. Without government intervention, potential knowledge spillovers from green innovation can further hinder development of clean fuels.

Figure 20. Taxes on petrol and diesel contribute to effective carbon rates in road transport

Average effective carbon prices (left axis) and GHG emissions (right axis) by sector in Canada, 2021



Note: Net effective carbon tax rates and its components (LHS) are averaged across all domestic GHG emissions, including those not covered by any carbon pricing instrument. Effective price information is for 2021, with the exception of fossil fuel subsidy estimates that are based on data for 2020. GHG emissions (RHS) are the sum of fossil-fuel related CO_2 calculated based on energy use data for 2018 from IEA (2020), World Energy Statistics and Balances, and "other GHG" from Climate Watch (2020), GHG Emissions (CAIT dataset), World Resources Institute.
Source: OECD (forthcoming), Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris.

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Maintaining tough emissions standards on combustion engine vehicles

Tougher vehicle standards could help lower tailpipe emissions. The impracticality of monitoring emissions from different types of cars creates a role for regulations to complement taxes on fuel. Emission standards for passenger vehicles will tighten in Canada between now and 2026. Since 1991 Canada has formally aligned light-duty vehicle standards with those in the United States. Aligning standards with its largest trading partner helps maintain a large export market for Canada's automotive manufacturers. It also avoids duplication of vehicle testing requirements across the border and ensures access to low-cost imported vehicles (Sharpe, 2018[73]). Canada has in the past proposed working with California on tougher standards (ECCC, 2019[74]). The participation of other large US states could improve the viability of such a plan. In contrast, unilateral action by Canada could threaten the benefits of the current regulatory arrangement.

Ensuring clean fuel regulations deliver intended benefits

Federal government policies also aim to reduce the carbon content of petroleum-based fuels and speed up the development of a local biofuel industry. The Clean Fuels Fund provides support for biofuels, including renewable diesel and cellulosic ethanol, which could offer relatively rapid-adoption means of lowering emissions. New Clean Fuel Regulations (CFR) tighten emissions-intensity standards on domestically-produced and imported petroleum-based fuels. Emissions-intensity benchmarks decline each year from 2023 to 2030, achieving an almost 12% reduction by the end of the decade.

Targets in Canada's CFR are set based on a fuel's lifecycle emissions, including upstream and downstream production. They can be met by fuel producers replacing petrol and diesel with biofuels. Alternatively, compliance can be achieved through action to reduce emissions along fuel supply chains – for instance, through carbon capture investment in oil and gas extraction. A tradeable credit system underpinning the regulations supports flexible compliance with the aim of reducing the policy's economic cost. Thus, for instance, fuel makers can choose to buy credits from other firms rather than undertake higher-cost abatement themselves. Carve-outs exclude certain categories of fuels from the scheme (gaseous and solid fuels) as well as certain sectors (e.g., aviation), exports, and the oil-producing province of Newfoundland and Labrador.

Protections in the rules guard against common pitfalls of pro-biofuel policies. This includes the risk of increased emissions caused by land use changes. Emissions can arise as agricultural land is repurposed to grow biofuel feedstock, while new cultivation in other areas disturbs natural carbon sinks. Policies to boost biofuel demand can also drive up food prices, benefiting landowners at the expense of consumers, including the world's poor (Wright, 2014[75]). The development and commercialisation of second-generation biofuels relying on inputs like crop wastage and municipal landfill may mitigate some of these pitfalls. Canada's regulations stipulate that biofuel production must not risk indirect land-use changes that harm the environment; crops must not be used as biofuel feedstocks. Other provisions try to head-off crude oil "shuffling" – redirection of clean oil to Canada and dirtier oils to foreign jurisdictions. If this were to occur, low-carbon fuel standards might distort behaviour without reducing global emissions. It is conceivable emissions could actually increase through diverted transport of global commodities.

Such provisions, while well intentioned, may be hard to enforce. Verification of processes for manufacturing imported fuels, and their indirect effects, will be particularly challenging. For instance, CFR incentives recognise biofuels made from crop residues and damaged crops but not crops that have been intentionally altered. Only systematic review of the scheme's impact will determine whether it functions as expected. This should be done early to reduce risk of unintended consequences.

Regular evaluation should also investigate interactions with other policies. CFR incentives for reducing upstream oil and gas emissions – for instance via credits for carbon capture and storage – could lower allowance prices in large emitter programmes (Pembina Institute, 2022[76]). This might require more active management of carbon credit markets to avoid gluts in allowances that undermine carbon pricing signals.

Together with motor vehicle fuel taxes, the CFR will also alter relative abatement incentives by raising effective carbon rates for petroleum producers above rates in other sectors. Thus, for instance, fuel manufacturers may face stronger incentives to decarbonise production than companies producing cement. This makes it less likely that market forces drive abatement in businesses able to do it at the lowest cost, undermining the efficiency of climate policies.

Re-targeting support for zero emission vehicles

Federal and provincial climate plans put a large focus on take-up of zero emission vehicles (ZEVs), especially electric vehicles. This is appropriate, as achieving Canada's 2050 emission target depends on bringing motor vehicle tailpipe emissions as close to zero as possible.

There is a case for government support of zero emission vehicles, for now. While ZEVs are only a small share of all motor vehicles (0.8% in 2020), purchases are increasing (Dunsky Energy & Climate, 2022[72]): 8% of new cars sold in the first half of 2022 were ZEVs (S&P Global Mobility, 2023[77]). Government intervention in the market helps resolve a well understood coordination problem. Demand for electric vehicles depends on ready supply, and on available charging infrastructure. Supply of ZEVs and chargers in turn depends on strong demand.

A promised ban on new internal combustion engine (ICE) vehicle sales sends a useful signal. A proposed federal mandate would impose a 100% ZEV target for sales of new light-duty vehicles by 2035. An interim target of ZEVs reaching 60% of new sales by 2030 is consistent with a global net-zero scenario published by the IEA (IEA, 2022[78]). Sales mandates can be effective as an early signal to carmakers about the future direction of climate policy. They also aid projections of future charging infrastructure needs. This can stimulate private supply while helping local authorities to plan ahead. Given the average lifespan of cars (around 12 years, based on a recent estimate for the United States by S&P Global Mobility (2022[79])), and Canada's plan to decarbonise electricity by 2035, it makes sense to support ZEV take-up now, even in provinces still reliant on fossil fuels for power.

ZEV mandates exist already in Canadian provinces Quebec and British Columbia, California, and countries including China (Axsen, Plötz and Wolinetz, 2020[80]). France is among the OECD countries to have declared a goal of banning new ICE vehicles in coming years. An equivalent ban is due to apply across the European Union from 2035. Once in place, ICE vehicle bans will impose some important costs: reducing some car makers' profits, constraining consumer choice and, until cost gaps close with combustion engine vehicles, increasing new car prices. Policy design choices can reduce these costs. Enabling trade in credits earned by selling zero emission vehicles, in particular, encourages ZEV manufacturing to start with producers able to do it cheaply. On a global level, supply constraints – including shortages of raw materials such as lithium and nickel needed to make EV batteries – may limit the rate of ZEV take-up this decade (IEA, 2022[81]).

Demand-side measures to accelerate electric vehicle uptake include public procurement policies, grants and tax breaks for EV purchases, and support for charging stations. The federal government offers a rebate of CAD 5 000 for purchases or leases of new ZEVs. Federal rebates are typically available on top of grants offered by provinces (Table 5).

Table 5. Selected electric vehicle purchase support schemes in Canada

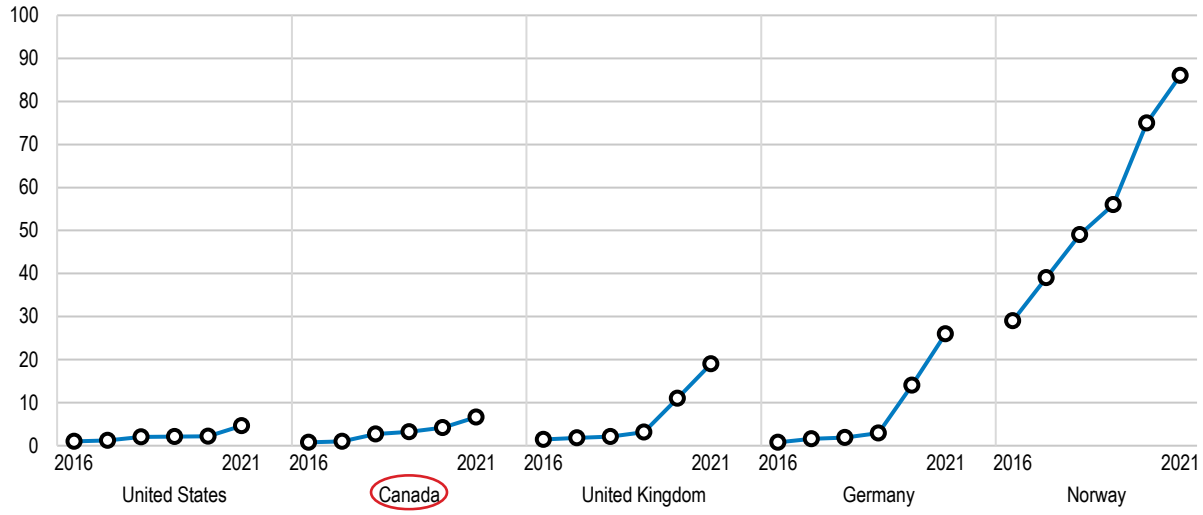
	Maximum rebate	Indexed to income?	Available for high-value vehicles?	Available for second-hand cars?
British Columbia CleanBC Go Electric	CAD 4 000	Yes	No Max CAD 55 000 for cars	No
Quebec Roulez vert	CAD 7 000	No	No Max CAD 60 000	Yes CAD 3 500
Nova Scotia Electrify Rebate Programme	CAD 3 000	No	No Max CAD 55 000 for cars	Yes CAD 2 000
New Brunswick EV Rebates	CAD 5 000	No	No Max CAD 55 000 for cars	Yes CAD 2 500
Federal Government iZEV	CAD 5 000	No	No Max CAD 55 000 for car.	No

Source: CleanBC Go Electric (2022[82]), Government of Quebec (2022[83]), EV Assist Nova Scotia (2022[84]), NB Power (2022[85]), Transport Canada (2022[86]).

Like supply-side support, demand-side measures should be phased out when markets become self-sustaining. The costs of reducing emissions through rebates tend to be relatively high (Box 13) (Clinton and Steinberg, 2019[87]), particularly after accounting for abatement induced by other climate policies. A portion of ZEV support is likely capitalised in higher prices. Some benefits go to households and businesses that would have bought ZEVs without assistance. Lower running costs in provinces with cheap electricity provide a strong incentive already, particularly for well-off households with limited credit constraints. Vehicle maintenance is also expected to be lower for EVs compared with ICE vehicles (US Department of Energy, 2022[88]). Carbon price rises will similarly increase the appeal of zero-emission vehicles by making petrol and diesel more expensive. Subsidies should be scaled back as carbon price increases improve ZEV cost competitiveness. Fast-maturing markets in provinces such as British Columbia and Quebec (Table 6) may soon enable support to be tapered in parts of Canada, particularly as availability of lower-cost car models improves. EV incentives have been reduced in such a way in Norway (OECD, 2022[89]), where most new cars sold are electric (Figure 21). Incentives should in the meantime be re-targeted to avoid adverse distributional effects. In British Columbia, rebates are smaller for higher-income buyers. This supports take-up by middle and lower-income households and limits instances of grants benefiting wealthy households that might have bought ZEVs anyway (Borenstein and Davis, 2016[90]).

Figure 21. EV sales have increased but are lower than in more mature markets in Europe

Electric vehicle (EV) sales share, %



Note: EVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).
Source: IEA (2022), Global EV Data Explorer, IEA, Paris.

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Table 6. EV share of new car sales by Canadian province

Province	Q4 2021	Q4 2022	Change (pt)
British Columbia	15.3%	20.1%	4.8
Quebec	9.8%	14.6%	4.8
Ontario	4.9%	8.3%	3.4
Alberta	2.8%	4.4%	1.6
Manitoba	2.1%	3.2%	1.1

Source: S&P Global Mobility (2023[77])

Box 13. Illustrative estimate of the abatement cost of EV rebates

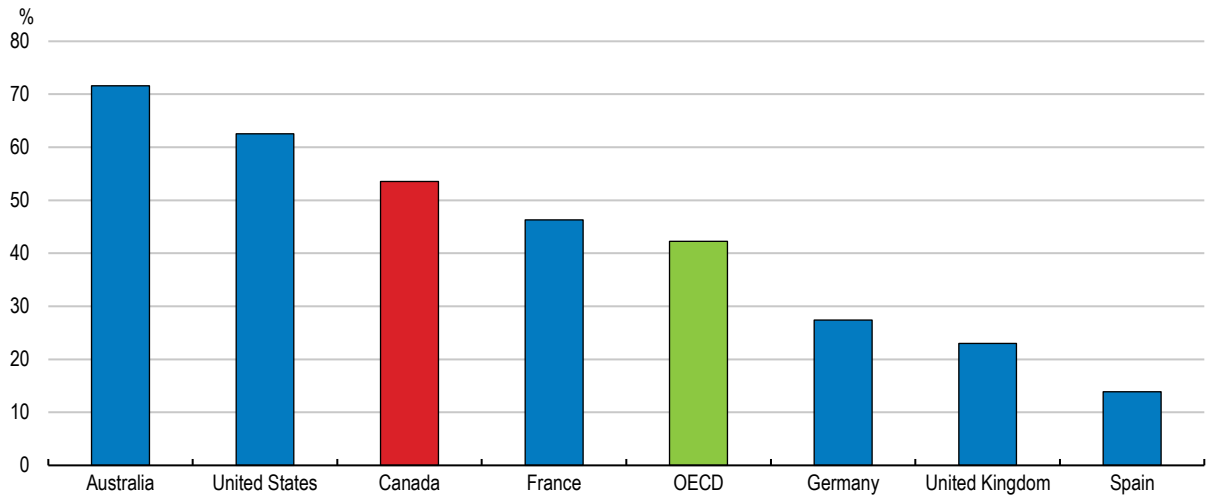
In some provinces, the combined value of provincial and federal rebates is large. In Quebec, with extra assistance from federal-government grants, purchasers can receive CAD 12 000 for light-duty vehicles valued up to CAD 60 000. A rough calculation provides insights into the costs of such incentives relative to other abatement instruments. IEA estimates, based on lifetime emissions from mid-size cars in places with clean electricity, suggest replacing an ICE vehicle with a ZEV could remove 32 tonnes of CO_2. Based on a subsidy of CAD 12 000, this translates to a cost of around CAD 375 per tonne of CO_2, well above the peak in Canada's carbon price floor this decade of CAD 170 in 2030. At its current floor (CAD 65), carbon pricing would remove almost six tonnes of CO_2 for the cost of eliminating one tonne via ZEV rebates.

Gaps in electric vehicle charging networks can pose a barrier to EV take-up. A 2022 report commissioned by Natural Resources Canada found that, to stay on track for a 2035 ban on new ICE vehicles, Canada would need a 43% increase in installed fast-charging ports by 2025 (from 3000 to 4300) (Dunsky Energy & Climate, 2022[72]). The size of the Canadian landmass complicates the task of equipping highways with charging infrastructure. But charging demand will be greatest within towns and cities. Many people will end up charging at home. Outside Canada's busiest cities, most people live in detached houses, where space for parking makes home charging easier and reduces the need for new infrastructure (Figure 22). In contrast, public charging stations will be more important in urban areas where more people live in multi-unit buildings.

Federal government support aims to accelerate development of charging networks. CFR credits and direct funding are available for providers of charging stations. Provinces similarly support EV charging infrastructure projects. The experience of countries with more developed electric vehicle markets, such as Norway, suggests that charging operators will increasingly build fast-charging stations without subsidies (D'Arcangelo et al., 2022[8]). Better government support programmes in Canada prioritise projects less likely to attract unsubsidised private investment, and support potential investors with information on projected future demand. Charging support should be complemented with regulations. Some municipalities (for example, the City of Vancouver) already require charging infrastructure to be installed in petrol stations and commercial carparks. Building codes could require charging infrastructure for new buildings with off-street parking, as well as major retrofits. Provinces and municipalities have a role in setting rules around installation, approval and cost sharing for electrical infrastructure in apartment buildings. Some have started doing this already, including the Condominium Authority of Ontario (KPMG, 2022[91]).

Figure 22. Detached houses are common in Canada

Detached houses, % of occupied dwellings, 2020 or latest year



Source: OECD Affordable Housing Database.

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Supportive policies to encourage active transport and public transport

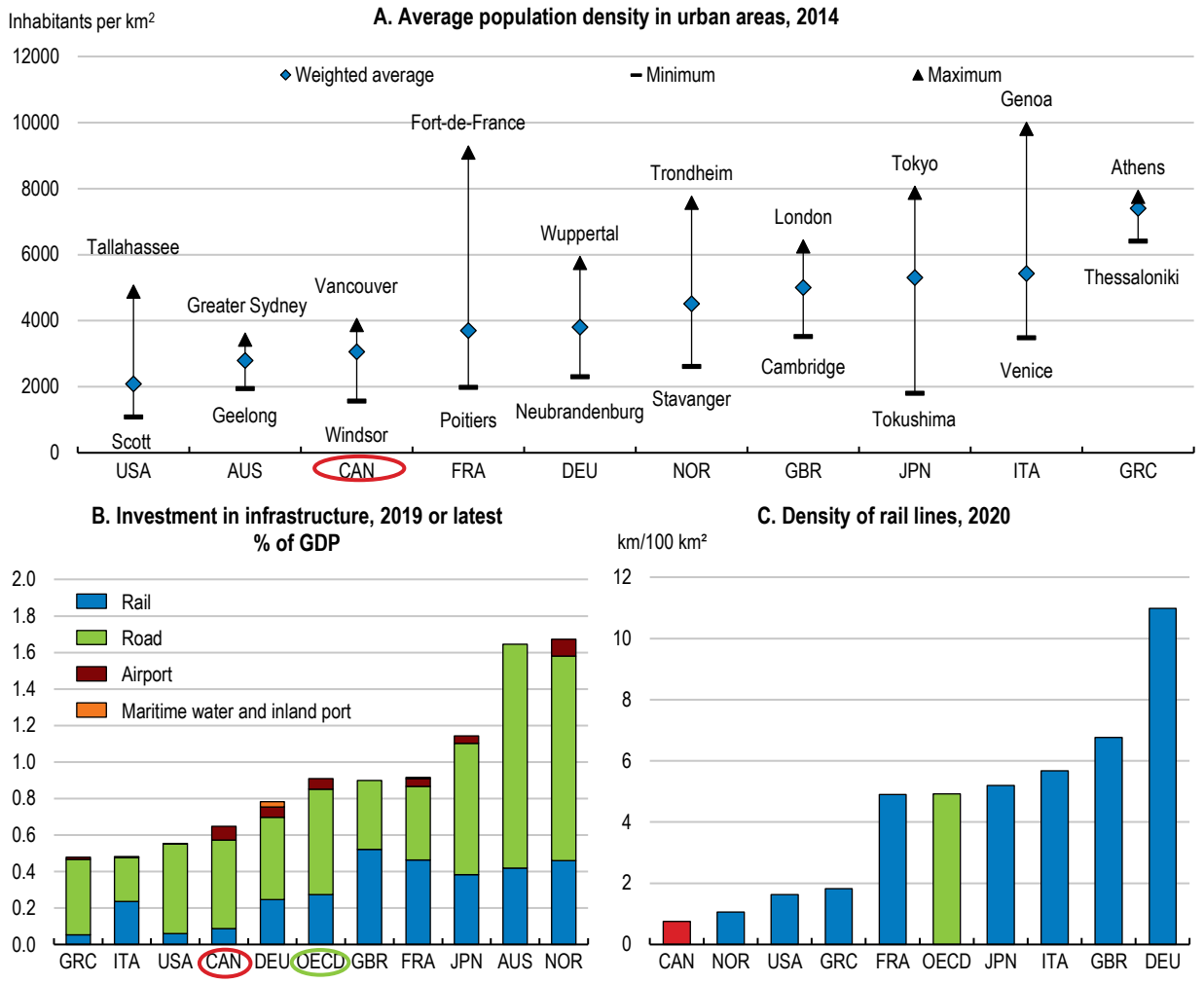
Policies to reduce car use will be essential to achieve large emission reductions from road transport (Canadian Institute for Climate Choices, 2021[92]). Longer-term reductions in kilometres driven will depend on more compact cities and denser transport networks. Less driving would reduce both emissions from burning petrol and diesel in ICE vehicles, and embodied emissions in car parts. Cars bring non-environmental costs also, including noise and air pollution, road deaths, and congestion in cities – these, too, would decline with less car use.

Geography can be a barrier to expanding use of public transport in parts of Canada. The COVID-19 pandemic and associated increase in teleworking significantly reduced public transport use in Canada's cities. Ridership across trains, buses and metro lines is yet to recover to pre-crisis levels. Intercity bus services faced major challenges before the pandemic, with declining ridership rates and profitability on low-density routes (Transport Canada, 2019[93]). Rail also has cost disadvantages in servicing regions of low population density.

Restrictive land use rules impede densification and reduce returns to public transport infrastructure investment. Access to jobs via public transport differs across cities (Allen and Farber, 2019[94]). In Vancouver, integrated transport and land use planning, and a policy of lifting the density of housing around the transit network, has contributed to higher rates of public transport use than in comparable regions of Canada (Huerta Melchor and Lembcke, 2020[95]). On the whole, however, public transport access tends to be worse in Canadian cities than in more compact European cities with denser road networks (Wu et al., 2021[96]). Walking and cycling ("active transport") similarly can be less practical for getting to work in sprawling urban centres common in parts of North America (Figure 23) (OECD, 2021[97]).

A key priority is to remove barriers to higher-density housing in urban areas close to public transport. Relaxing overly stringent zoning limits on building heights, urban infill, and other density restrictions could indirectly help to improve the viability of urban public transport routes and reduce need for cars. An added benefit would be to make housing more affordable and improve access to jobs for lower-income households. Increased use of road tolls, complemented where feasible by reallocation of urban road space to other transport modes, could similarly increase the appeal of active and public transport in cities and use of inter-city bus and train services. Road user charging will become more important for government budgets as ICE vehicles decline in number and associated fuel tax revenues shrink. Canada's federal and provincial governments collect just under 2% of national GDP in road transport revenues (Transport Canada, 2019[98]), of which the bulk is from fuel taxes.

Figure 23. Canada's low population density has tended to favour investment in roads



Note: Panel A: The weighted average urban population densities are at the country levels, and the minimum and maximum urban population densities are at the city levels. Panel B: OECD unweighted average excludes Colombia, Costa Rica and the Netherlands. The lack of common definitions and practices to measure transport infrastructure spending hinders comparisons between countries. While the ITF survey covers all sources of financing, a number of countries do not include private spending. Caution is therefore required when comparing investment data between countries. Panel C: OECD unweighted average excludes Australia, Colombia, Costa Rica, Iceland, and New Zealand.
Source: OECD (2022), "Metropolitan areas", OECD Regional Statistics (database); and OECD Transport database.

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Decarbonising road freight transport

Heavy-duty vehicles account for around 40% of road transport emissions. Most freight in Canada is moved by trucks (90% in 2017) (Statistics Canada, 2020[99]). Rail is an important means of transport for goods including farm products but comprises a smaller share of freight transport (9% in 2017), reflecting high infrastructure costs in large, sparsely populated regions. Road freight volumes and associated emissions will increase with economic activity. There is overlap in the tools used to decarbonise transport of goods and those needed to reduce passenger vehicle emissions.

Policies to encourage lower-carbon goods transport need to accommodate different technologies. A key challenge for decarbonising road freight is that no one technology as yet looks likely to solve the problem alone, particularly for long-haul trucking (ITF, 2021[66]). Two front-runners are battery electric trucks and hydrogen fuel cell trucks. Both require new powertrains and refuelling infrastructure (BCG, 2021[100]). Biofuels can reduce emissions using existing trucks and fuel pumps but remain expensive next to diesel. A combination of technologies looks likely to be deployed to decarbonise road freight, at least in the near term (Table 7). This complicates design of government support. Existing technology-neutral policies such as carbon pricing will play an important role. Together with the CFR, fuel levies will reduce cost gaps and encourage development of cleaner fuels and vehicles. Tighter vehicle standards will also push the industry towards more fuel efficient and lower-emission vehicles.

Governments also have a role in sponsoring research and development. Canada's size adds to the cost of rolling out charging and refuelling infrastructure. Still, substantial decarbonisation can be achieved in coming years through decarbonising logistics over the country's most-trafficked inter-city connections (Kayser-Bril et al., 2021[101]). Governments should collaborate on pilot projects covering such routes and test technologies deployed in other OECD countries for use in Canadian conditions, including extreme winters in parts of the country (Box 14). Support for emerging technologies such as green hydrogen should also continue, ensuring provincial schemes benefit from lessons learned in other Canadian jurisdictions and abroad.

Table 7. Pros and cons of low-carbon trucks and fuels

Technology	Pros	Cons	Possible application
Battery electric trucks	Can be zero carbon	Batteries displace payload Range loss in the cold Requires new trucks and charging infrastructure	Smaller vehicles and payloads, shorter trips
Hydrogen fuel cell trucks	Can be zero carbon	Requires new trucks and fuelling infrastructure	Medium to long-distance transport, high-service vehicles
Catenaries	Demonstrated technology in urban areas	Large fixed investment costs to electrify highways	Longer trips over fixed, high-trafficked routes
Biodiesel/renewable diesel	Uses existing trucks and fuelling infrastructure	Emissions from indirect land use change, limited feedstock availability	Replace diesel fuel using existing trucks
Synthetic E-diesel	Uses existing trucks and fuelling infrastructure	Not yet on the market, cost-prohibitive, energy-intensive production	Replace diesel fuel using existing trucks

Source: BCG (2021[100]).

Box 14. Testing green technology in cold conditions in Canada

Extreme cold affects the productivity and cost of green technologies in parts of Canada. This has implications for policies to reduce cost gaps with higher-carbon technologies. Some cases call for pilot projects or government-funded research and development to adapt market-ready solutions for Canadian conditions:

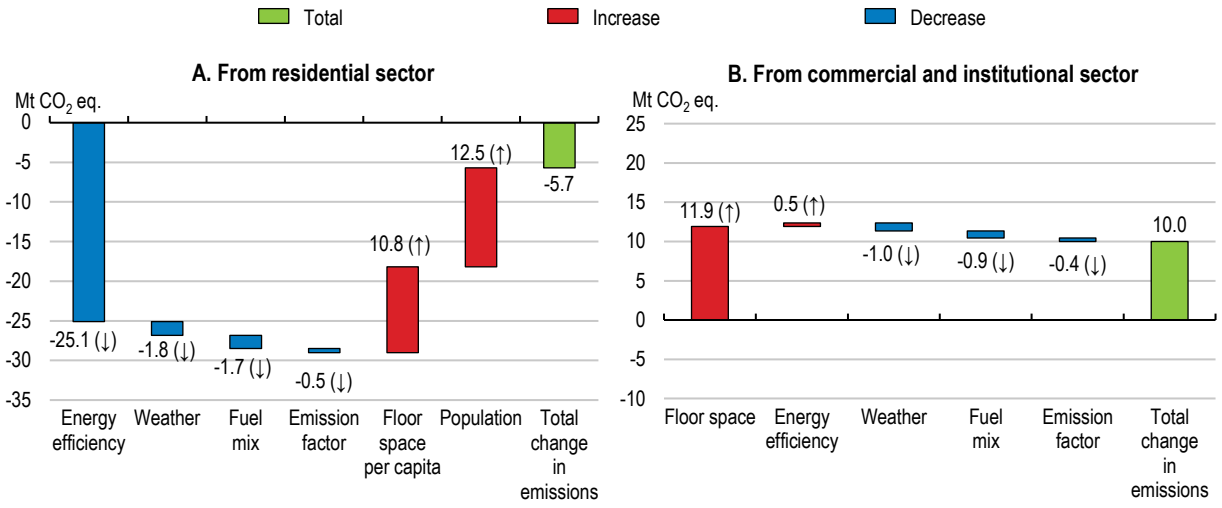
- **Trucking** – Battery chemistry and energy consumed for heating causes electric vehicles to lose range in very cold weather: battery electric trucks could lose 25 to 35% of their range in -20°C (Sharpe, 2019[102]). In contrast, using catenaries to electrify highways – as is done in urban tramway systems – might have advantages in Canada (Kayser-Bril et al., 2021[101]). Catenaries already electrify some roads in Germany and Sweden. A recent study suggested testing catenaries on specific high-trafficked routes in Canada, including to see how they withstand extreme cold in winter (Kayser-Bril et al., 2021[101]).
- **Heat pumps** – Typically highly-efficient electric heat pumps are less effective at extracting warmth from outside air at very low temperatures. Use of special cold climate pumps can solve this issue, but with inefficiencies – most days of the year houses could get by with lighter-duty heat-pump systems. Research into alternative solutions such as hybrid natural-gas and electric heat pumps could offer a more cost and energy-efficient solution (IEA, 2019[103]). Ontario recently rolled out a hybrid heat-pump scheme which will be tested in a range of climates (Government of Ontario, 2022[104]). Natural Resources Canada is also working with the US Department of Energy, the US Environmental Protection Agency, and manufacturers on developing high-performance cold-climate heat pumps through the Residential Cold-Climate Heat Pumps Technology Challenge (U.S. Department of Energy, 2021[105]).
- **Wind power** – In Quebec and in Canada's Atlantic provinces, wind energy has advantages over solar since power demand and wind speeds both peak in the winter. However, performance of normal wind turbines can decline in extreme cold: accumulation of ice increases rotor loads and reduces power output (Natural Resources Canada, 2017[106]). Add-ons, such as heaters to avoid ice build-up, can improve the function of wind turbines in very cold weather.

Improving the energy performance of Canada's buildings

Greenhouse gas emissions from homes and service-industry buildings made up 13% of Canada's total emissions in 2020. The bulk comes from burning natural gas and oil to heat rooms and water (78%). From year to year, differences in weather can drive substantial movements in buildings-sector greenhouse gas emissions, making comparisons between years difficult. Overall, however, emissions from homes have been relatively stable since 1990. Expansion in the housing stock has been offset by energy-efficiency improvements and declining use of fuel oils for heating (Figure 24). In contrast, increased service-industry floorspace has contributed to rising emissions from commercial and public buildings. In 2019, GHG emissions from service-industry buildings made up 53% of the building-sector total, more than those from homes (47%).

Figure 24. Increased floorspace has offset the emissions impact of energy-efficiency improvements in some sectors

Contributions to change in stationary GHG emissions from 1990 to 2020



Source: ECCC (2022), National Inventory Report 1990–2020: Greenhouse Gas Sources and Sinks in Canada.

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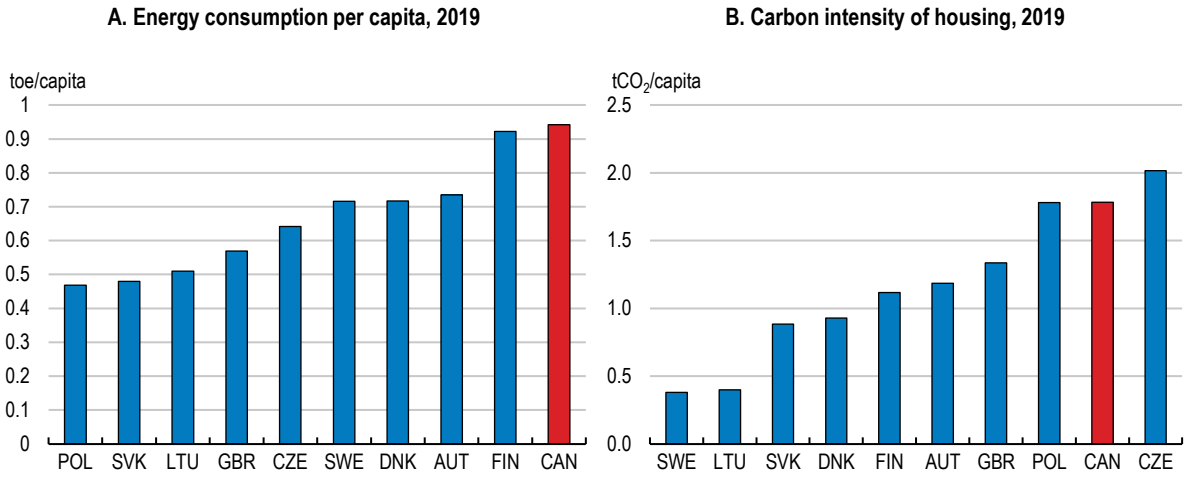
Canada's high rates of energy consumption compared with other cold countries partly reflect the size of its homes. Large volumes of natural gas and electricity are consumed powering houses and apartments that are large in international comparison (Figure 25). Low prices also encourage heavy use of electricity and natural gas. Natural gas heating systems are common in Canada's western provinces, where gas is particularly cheap.

To reach net zero emissions, fossil fuel heating systems must be phased out and energy use in buildings must decline. This will be important both to reduce emissions from the buildings sector itself, and to free up low-carbon electricity for other sectors, such as transport and heavy industry. Canada's Green Buildings Strategy aims to bring net emissions from buildings to zero by 2050. An interim 2030 goal of a 37% reduction from 2005 levels is in place to keep the process on track. While the federal government influences sub-national policy, the provinces – and in some cases municipalities – are responsible for regulating construction and buildings. The main policy instruments for achieving target GHG reductions differ for new and existing buildings.

Figure 25. Energy use and emissions from housing are high relative to other cold countries



Note: Countries are classed as having a similar climate when the number of heating degree days is above or equal to 2.9. Heating degree days are the number of days where the average temperature falls below the level at which residents typically turn on heating. The residential sector's energy consumption includes space heating and cooling, water heating, cooking and appliances.
Source: OECD (2021), Brick by Brick: Building Better Housing Policies, OECD Publishing, Paris.

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Setting tougher energy performance standards for new buildings

Energy-efficient new buildings are essential for hitting emissions targets in coming decades. Continued construction at rates registered in recent years would quickly see new buildings' share of the stock expand. Recent capital stock data suggest that by 2050, buildings constructed after 2020 could comprise over half the total stock. Even if rates of construction decline from recent levels, new buildings will still have a large impact on the sector's environmental performance. This reinforces the importance of setting strict energy standards now.

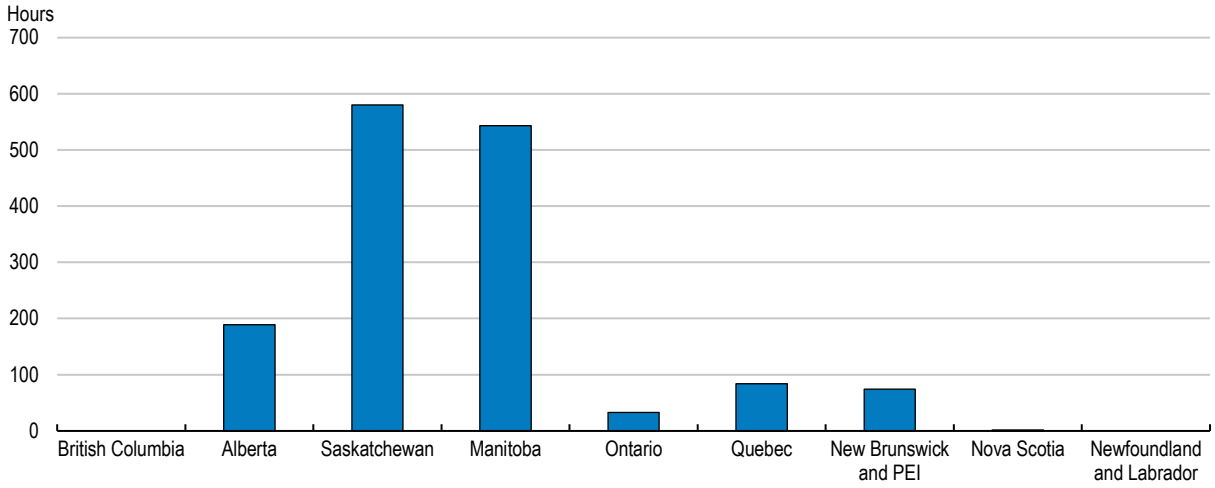
National building codes set increasingly stringent energy-efficiency requirements. The federal government maintains and regularly tightens a model energy code, called the National Energy Code of Canada for Buildings (NECB). The latest version of the code (NECB 2020) enhances previous minimum energy-efficiency standards for building envelopes, ventilation, and water and space heating systems. Also included in the code are tiers of more stringent energy performance requirements, which provincial governments or builders can elect to follow. These are designed to foreshadow the future direction of building policy. The most stringent performance tier prescribes standards consistent with net zero energy-ready buildings (buildings that are so efficient they can rely solely on renewable generation, on or off-site, for their energy needs). Incorporation of such standards in provincial building codes could align building performance in Canada with that of leading OECD countries such as Norway.

Provincial adoption of the latest energy code must happen quickly

For it to be enforceable, the national energy code must be adopted into provincial regulations. Most provinces adopt the energy code, in whole or in part, or have local rules with equivalent effect. However, provinces often adopt the code's latest iteration with a significant lag (Table 8). A minority of provinces apply the current code or have local standards that are at least as stringent. A larger number of provinces apply older, less strict versions of the code (in whole or in part), often with modifications for local conditions (Figure 26). The result is significant divergence in building energy standards across the country.

Figure 26. Building codes must account for significant climatic variation

Average hours per year below -20ºC, 2015-20



Note: The chart shows average hours per year below -20ºC in the province's largest city.
Source: Haley and Torrie (2021[107]).

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Table 8. Adoption of National Energy Codes by selected provinces

	NECB 2011	NECB 2015	NECB 2017	NECB 2020
British Columbia	December 2013	December 2018	-	-
Alberta	November 2015	-	April 2019	-
Saskatchewan	-	-	January 2019	
Manitoba	December 2014	-	-	-
Ontario	January 2014	-	-	-
Quebec	-	June 2020	-	-
Nova Scotia	December 2014	April 2017	January 2020	-

Note: The table shows the date at which a given version of the National Energy Code for Buildings (NECB) entered into force in a particular province. No province has yet adopted the latest version of the code. However, British Columbia already applies a provincial code that is at least as strict as NECB 2020.
Source: Natural Resources Canada.

Federal support can move provinces along more quickly. Processes exist already to harmonise building codes across provinces, including with a view to lowering inter-provincial trade barriers. The Construction Codes Reconciliation Agreement has been in place since 2019. There is no means, however, to force provinces to adopt the latest version of the model energy code. Other federalised OECD countries – including the United States – have in the past used national government funding to accelerate energy code

adoption (Buildings Codes Assistance Project, 2022[108]). This is being considered in Canada, with a proposal for a net zero building code acceleration fund. Such funding should aim to address capacity shortfalls in sub-national governments which delay code adoption. The federal government could support adjustment to the latest code with funding for training, guidelines, and information to assist compliance (Lockhart, 2021[109]).

Phasing out fossil fuel heating should be a priority

Fast action by the provinces will be needed to catch up with leading OECD countries that are already moving towards net zero emission codes, including Norway (OECD, 2022[89]). So far only British Columbia has committed to a zero-carbon code (by 2030). Action in other provinces must follow. The immediate priority should be to set a timeframe for phasing out fuel oil heating – the most emission-intensive way to heat buildings. Bans on oil burners have already been imposed or announced in OECD countries including Germany, France, Sweden and the United Kingdom (IEA, 2022[110]). While most countries focus on restricting installation of emission-intensive heating systems in new buildings, some including Norway also require replacement of oil burners in existing buildings.

In Canada, Quebec is among the few jurisdictions to have set a deadline for phasing out fuel oil heating (2030). Electrification rates, and use of energy-efficient heating systems, are likely to pick up elsewhere in Canada with rising carbon costs. Without regulatory intervention now, however, continued installation of conventional fossil fuel heating systems may necessitate expensive retrofitting further down the track. To avoid this, the federal government should follow through on a commitment to set a timeline for phasing out emission-intensive fossil fuel heating.

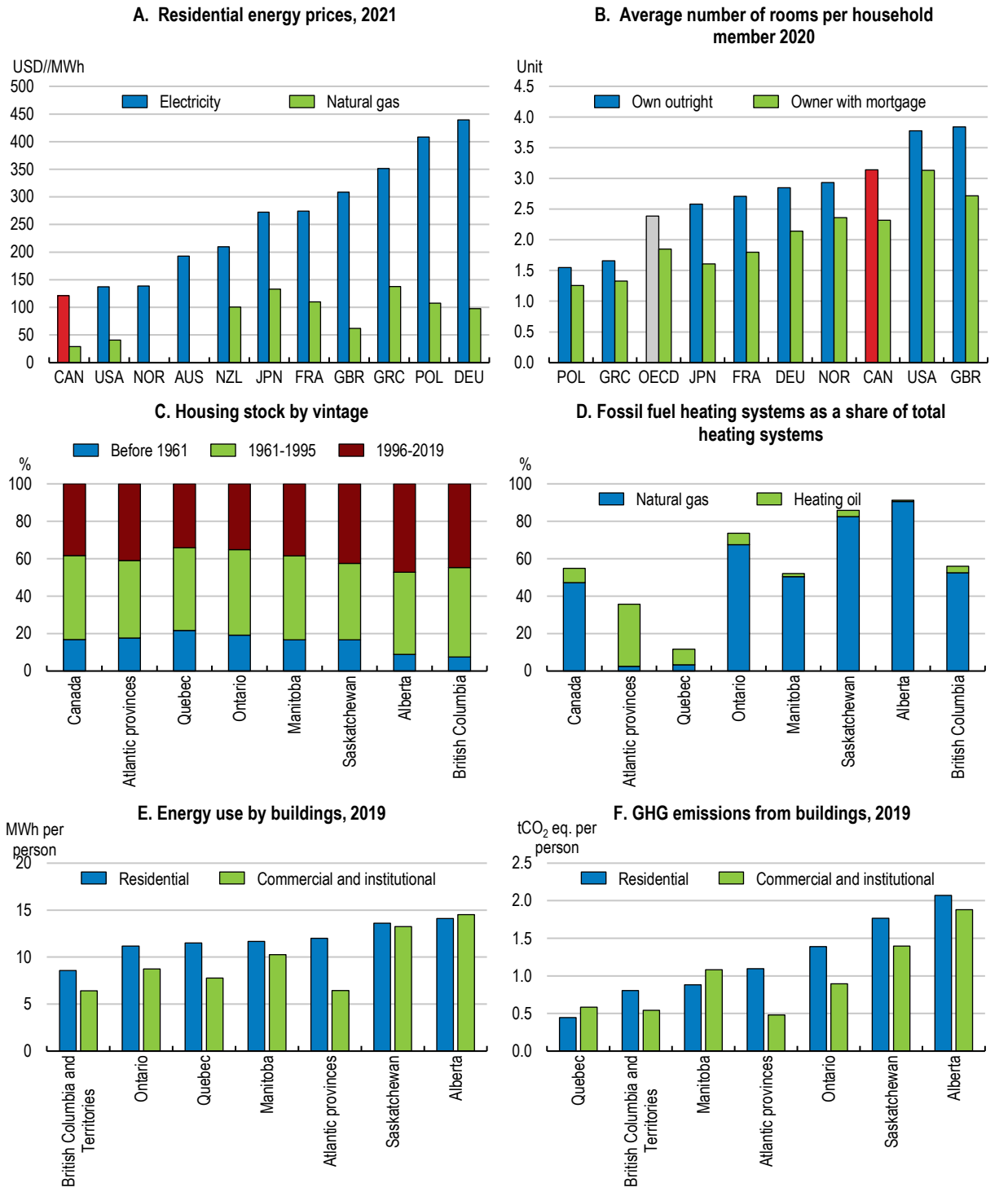
Accelerating retrofitting of existing buildings

A tougher policy challenge is to reduce energy use and emissions from existing buildings. The age and energy performance of existing structures varies considerably across the country (Figure 27). Most were built to comply with less stringent energy performance requirements than those found in Canada's current energy code. Heating residential buildings constructed before 1960 can consume almost three times the energy required to heat the same amount of space in Canada's newer dwellings (IEA, 2019[111]).

Current retrofitting rates are too low to achieve required emissions reductions from the existing stock of buildings. A study by Efficiency Canada found that 0.7% of homes are retrofitted each year and 1.4% of commercial floorspace (Haley and Torrie, 2021[107]). At these rates, the authors conclude it would take around 140 years to retrofit homes and 70 years to upgrade other buildings.

Canada's federal and provincial governments provide loans, grants and energy-saving advice in an effort to lift retrofitting rates. Among the subsidised investments are home insulation, air sealing, installation of renewable energy systems and electric heat pumps. Other programmes focus on supporting retrofitting of low-income housing. A federal government drive to promote energy-performance certification complements loans and grants. Voluntary certification is available for high-performing buildings through the Energy Star programme. Federal programmes also provide funding for bioenergy initiatives – including biomass-based district heating systems – in Indigenous, rural and remote communities. This has been a focus of the Clean Energy for Rural and Remote Communities Program, which works to reduce reliance on fossil fuels for heating in off-grid communities (Box 9).

Figure 27. Low energy prices compound the retrofitting challenge



Note: Panel D: The chart shows the share of heating systems in residential buildings that are fossil-fuel based. Not shown are electric, wood and dual heating systems. Panel F: Emissions exclude industrial process and product use emissions. These include halocarbons from building cooling and refrigeration. When they are included along with emissions from energy use, total greenhouse gas emissions from commercial and industrial buildings were larger than those from homes in 2019.

Source: IEA (2022), Energy prices and taxes (database); OECD Affordable Housing Database, National Resources Canada (2022), National Energy Use (database).

StatLink 2 https://stat.link/zaubhg

The overall mix of support provided by governments is well-adapted to overcome barriers to energy-efficiency improvements. Grants and loans can help credit-constrained households undertake renovations that ultimately reduce their energy bills. The provision of advice can help owners pursue cost-effective energy-saving investments that might otherwise be harder to identify. Standard energy-performance certification, if rolled out consistently across Canada's provinces, could better ensure property prices reflect a structure's quality. This would improve incentives for retrofitting in situations where owners and residents have conflicting incentives (Gerarden, Newell and Stavins, 2017[112]).

Some schemes could be retargeted. Loans and grants available through the federal Green Homes Initiative offer funding to all households, including those with high incomes. Many well-off households would likely undertake energy-saving renovations without support. Governments might achieve bigger emission reductions with larger incentives aimed at lower and middle-income homeowners more likely to face financial constraints. The new federal *Oil to Heat Pump Affordability Grant* is better targeted than other initiatives. Designed to accelerate the phase-out of carbon-intensive oil heating systems, mostly from Atlantic Canada, the programme offers grants of up to CAD 5 000 to low and middle-income households switching to cold-climate heat pumps (Natural Resources Canada, 2022[113]). In provinces with heavily regulated power markets, electricity pricing reform could further improve incentives for energy saving (discussed above) while generating resources for expanded retrofitting support. Provinces should in general avoid untargeted temporary energy relief measures (Box 15).

Energy-efficiency support to businesses should focus on addressing information gaps. Incentives targeted at firms include investments by the Canada Infrastructure Bank and rebates for energy-saving investments in Ontario. Governments can play a useful role in distributing information to firms to aid energy-saving investments. Small businesses in particular could benefit from this style of support: British Columbia's regulated utility Fortis BC offers free advice to small firms. In general, businesses should have strong enough incentives already to reduce the cost of the energy they consume.

There is a need for more systematic analysis of retrofitting programme effects. Governments should routinely evaluate the effects of existing schemes to check they perform as expected. Studies of past programmes in other countries have found instances where retrofitting schemes' costs exceeded their benefits (Fowlie, Greenstone and Wolfram, 2018[114]). Weatherisation schemes have also been found to disproportionately benefit the wealthy (Borenstein and Davis, 2016[90]). Evaluations could be facilitated by a recently announced strategy to improve modelling on the environmental effects of federal government programmes.

Box 15. Re-assessing utility bill subsidies: living-cost relief during the energy crisis

Past government policies have reduced private incentives for energy efficiency investments. Amid the energy crisis in 2022, some provincial governments introduced untargeted subsidies to shield households from temporary spikes in fuel prices and utility bills. While some support was needed to relieve living-cost pressure on vulnerable individuals and families, subsidies also benefited higher-income households. Equivalent resources, if instead allocated to retrofitting incentives, could have a longer-lasting impact on energy affordability while also reducing energy-use emissions.

Reducing emissions embedded in building materials

Like other OECD countries, Canada has until recently put little emphasis on reducing embodied emissions (including those generated to make, transport and assemble building materials). Significant fuel use and industrial process emissions arise from the manufacturing of cement and steel. Carbon pricing systems in Canada create incentives to reduce such emissions. These signals will strengthen with higher carbon prices and gradual tightening of minimum emissions-intensity standards. The federal government has appropriately started to pull together a broader strategy for reducing both carbon embodied in construction materials and greenhouse gases emitted from ongoing use of buildings.

In 2022 the National Research Council Canada released national guidelines for whole-building life-cycle carbon assessment (Bowick et al., 2022[115]). Lifecycle analysis could improve the environmental impact of building codes in Canada, including by better targeting of renovation rules. More broadly, lifecycle analysis will help assess the effectiveness of policies to reduce emissions associated with buildings.

Another priority should be to identify regulatory barriers to greater use of low-carbon and recovered building products. Ensuring building codes permit the use of safe, low-carbon alternatives to new steel and cement could improve recovery of building materials and reduce need for new production. Government procurement of ultra-green buildings and materials will also help test and improve green products and create new markets for them. In 2021, Canada joined the United Kingdom, Germany and other countries in a pledge to buy low-carbon steel and concrete (UNIDO, 2021[116]). With low-carbon electricity in many provinces and a favourable climate policy environment, Canada is well placed to match efforts in leading OECD countries to produce green steel (Box 16).

Box 16. Progress in decarbonising steel production: a case study of Sweden

Producers in Sweden have developed and tested technology using green hydrogen to replace traditional coke-based blast furnace processes in steel manufacturing. Benefiting from access to low-cost stable and clean electricity, as well as government support, two projects are underway to develop industrial capacity to make steel from iron ore with close to zero emissions (see HYBRIT (2022[117]), H2 Green Steel (2022[118])). Complementing international efforts to grow markets for zero-carbon products, abatement incentives through the EU ETS encourage greener production of building materials such as steel and cement. While steel and cement producers currently receive all of their allocated emission allowances for free, the ETS encourages emissions cuts at companies able to profit from selling allowances to other firms.

With abundant hydroelectricity in some provinces, and government-sponsored green hydrogen projects, steel manufacturers in Canada could substantially decarbonise production in the years ahead. Some steelmakers, backed with government support, are already pursuing plans to develop "hydrogen-ready" facilities to replace blast furnace-based production. In 2022, ArcelorMittal announced that it had successfully tested the partial replacement of natural gas with green hydrogen in the iron ore reduction process at its steel plant in Contrecoeur, Quebec (ArcelorMittal, 2022[119]). Higher carbon rates and tighter emission benchmarks in large-emitter programmes will strengthen incentives to use greener methods for producing construction materials.

The OECD steel policy community – including the OECD Steel Committee and the Global Forum on Steel Excess Capacity – brings governments together to address challenges facing the steel industry (OECD (2022[120]), GFSEC (2022[121])). Recent contributions on decarbonisation include key indicators on steel decarbonisation progress and monitoring of low-carbon steel projects. Through its membership in both fora, Canada can support and benefit from international cooperation to advance steel decarbonisation.

Source: OECD (2023[122]).

Policies to reduce the cost of climate change

Canada's climate is already changing

Average temperatures across Canada increased by 1.9 degrees Celsius (°C) from 1948 to 2021. This is double the global average rate of warming (Bush and Lemmen, 2019[123]). Temperatures will continue to increase, even if coordinated global action succeeds in curbing emissions (Bush and Lemmen, 2019[123]). Warmer temperatures threaten human health, diversity of flora and fauna, the resilience of ecosystems (Council of Canadian Academies, 2019[124]), and economic wellbeing.

As in other countries, climate change has brought more extreme weather. Canada is already experiencing more episodes of extreme heat, shorter ice cover seasons and rising sea levels (Bush et al., 2022[125]). Impacts are set to intensify, with costs compounded by concentration of assets in disaster-prone areas (Table 9).

The impacts of climate change will be uneven, with slow onset events such as permafrost thaw and sea-level rise adding to costs from natural disasters. As in other areas of high latitude, warming is happening fastest in Canada's north (Bush et al., 2022[125]). Thawing permafrost will damage roads and impede access to remote communities. Costs will fall heavily, too, on provinces such as Alberta that have experienced some of Canada's worst fires and floods (Canadian Climate Institute, 2022[126]). Changing ocean chemistry from CO_2 absorption could cause fisheries to be among the worst affected businesses. Changes in water availability, and the seasonal timing and volume of river flows, could affect hydropower production. In contrast, owners of agricultural land may benefit from longer growing seasons and better conditions for high-value crops. Recent studies suggest that, on an economy-wide level, climate change could cause significant income losses in Canada (Box 17).

Table 9. Canada's highest loss years on record – by insured catastrophic losses

Rank	Year	Total insured losses (CAD)	Notable catastrophic weather events
1	2016	5.4 billion	Wildfire, Alberta
2	2013	3.5 billion	Floods, Alberta and Ontario
3	1998	2.6 billion	Ice storm, Quebec
4	2020	2.3 billion	Flood and hailstorm, Alberta
5	2018	2.2 billion	Rain and windstorms, Ontario and Quebec

Note: The table shows insured catastrophic losses. The total includes all events with a cost of CAD 25 million or more. For each year, major individual catastrophic events are cited. The figures exclude uninsured costs from natural disasters, which can be large (see, for example, Canadian Institute for Climate Choices (2020[127])).
Source: Insurance Bureau of Canada (2022[128]).

Box 17. Projected economic impacts of climate change

Estimates of the impact of climate change on economic activity are highly uncertain due to the assumptions required to generate them. Some international studies project that Canada, as a high-income northerly country, could see global warming have a small net positive effect on gross domestic product. These results conflict with findings in Canada-focused studies. Recent projections suggest climate change could cause significant losses to income in Canada (), particularly if governments fail to take preventive action (Canadian Climate Institute, 2022[126]).

Table 10. Recent estimates of the impact of climate change on Canada's GDP

	GDP impact from +2C by 2050
Swiss Re Institute (2021)	-7%
PBO (2022)	-2.4%
Canadian Climate Institute (2022)	-2%
Kahn et. al. (2019)	-0.6%
Moody's Analytics (2019)	+0.2%

Note: The cited studies differ in scope, contributing to differences in estimated effects. Swiss Re Institute models the impact of rising temperatures, accounting for uncertainties around severe outcomes; the estimate shown is the most severe of a range of scenarios. Kahn et al. (2019) study impacts related to deviations of temperature and precipitation from historical norms; the estimated impact is on *per capita* GDP. The PBO models impacts of rising temperatures and precipitation; the estimate assumes global temperature increases limited to 1.8 degrees Celsius. The Canadian Climate Institute accounts for impacts on health, infrastructure, and climate-sensitive sectors. Moody's Analytics analyses effects associated with sea-level rise, human health, heat effects on productivity, farm productivity, tourism and energy. Source: Swiss Re Institute (2021[129]), PBO (2022[130]), Canadian Climate Institute (2022[126]), Moody's Analytics (2019[131]), Kahn et al. (2019[132]).

Adaptation can reduce harms from climate change

The biggest climate risks for Canada include damage from increased flooding, thawing permafrost and heatwaves (Table 11). Work to address such risks, and reduce future costs from climate change, is happening fastest in regions that have experienced severe events in recent years. For instance, investments in fire prevention and flood preparedness in British Columbia followed a record-breaking heatwave, devastating wildfires and flooding, all in 2021. Earlier, in 2014, the city of Vancouver amended building design standards to account for projected sea-level rise out to 2100 (OECD, 2019[133]). Work is underway in Atlantic Canada to build sea walls and restore beaches in communities experiencing land subsidence. In the north, governments are reinforcing roads damaged by thawing permafrost.

Box 18. Canada is finalising its first National Adaptation Strategy

In November 2022, the Government of Canada released for consultation a National Adaptation Strategy. Due to be finalised in the coming months, the strategy will clarify roles and responsibilities on adaptation for governments across Canada as well as Indigenous governing bodies and non-government stakeholders. The strategy will also detail Canada's adaptation objectives and an evaluation framework to track progress on mitigating climate-related risks. Set to be updated every five years, the National Adaptation Strategy will be accompanied by "action plans" for the federal government as well as bilateral federal-provincial plans. The first federal government Action Plan was released in November 2022. Setting out measures to address priorities over the next five years – including initiatives discussed in this Paper – the Action Plan targets the five main focus areas of the National Adaptation Strategy: disaster resilience, health, biodiversity, infrastructure, and economy and workers.

Source: ECCC (2022[134]).

In other regions, progress has been more limited. Many governments are yet to implement adaptation strategies or act on risk assessments (Changing Climate, 2022[135]). In addition to factoring climate considerations into infrastructure planning, concrete efforts are needed to integrate adaptation into land use planning and building codes. This is important for discouraging building in unsafe locations while ensuring those exposed to hazards reduce their risk of harm. The federal government is allocating CAD 60 million over five years to accelerate use of "climate-informed codes" and standards for resilient infrastructure. As costs and potential returns can differ widely between alternative adaptation measures and the places in which they are deployed (OECD, 2015[136]), cost-benefit analysis should be used to identify priority initiatives.

Table 11. Major climate risks facing Canada and selected adaptation measures by government

Risk	Government level	Selected adaptation measures
Heavy rains and flooding	Local	Relocation of homes (Perth-Andover, NB) Modified building rules (Markham, ON)
Sea level rise	Provincial	Seawalls (PEI)
	Local	Coastline restoration (Percé, QC)
Thawing permafrost	Federal-provincial	Updated building standards (Federal and Quebec)
	Provincial	Monitoring ground temperature (Yukon) Rebuilding road embankments (NWT)
Heatwaves and fires	Provincial	Enhanced wildfire service (BC) Heat alert system (BC) Strengthen emergency health services (BC)
	Local	Urban forest management (Halifax, NS)
Ecosystem collapse	Federal	Assisted migration of plant species (ECCC)
	Provincial	Greenbelt protection (ON)
Degraded fisheries	Federal	Ocean acidification studies (Fisheries and Oceans Canada)

Note: Risks are taken from a Canadian Government-commissioned report by the Council of Canadian Academies. Selected governments and government bodies that have undertaken adaptation measures in recent years are shown in brackets.
Source: Council of Canadian Academies (2019[124]); Changing Climate (2022[135]).

Existing federal government training initiatives help close gaps in capacity in smaller municipalities, including through Natural Resources Canada's *BRACE* programme (Building Regional Adaptation Capacity and Expertise). Funding is available for local adaptation efforts, including through Infrastructure Canada's Disaster Mitigation and Adaptation Fund, which the federal government has committed to top up. Calls on the Fund are expected to increase as communities move from assessing risks to implementing adaptation plans (Canadian Climate Institute, 2022[137]). Technical support can also help local authorities assess the costs and benefits of alternative adaptation investments.

Information and research to assist public and private adaptation

The quality of information on climate change affects the capacity of governments, firms and individuals to prepare for change and mitigate future harms. Past studies suggest climate services, forecasting and early warning systems tend to have high benefit-to-cost ratios (OECD, 2015[136]). Federal authorities in Canada provide climate data and projections through online platforms *Climate Data Canada* and *Climate Scenarios Canada*. Updated scientific advice and risk modelling will make it easier for provincial and local authorities to identify vulnerabilities and prioritise adaptation investments.

Research priorities identified in ECCC's 2020 report *Climate Science 2050* include natural defensive infrastructure, community design, and the impact of climate change on ecosystems (ECCC, 2020[138]). The federal government is funding a national climate science assessment, which will provide new data and information about ongoing and future climate change in Canada and support adaptation efforts.

Better flood maps are needed for quantifying and managing risks of flooding (OECD, 2016[139]), Canada's most common and costly natural disaster. Existing flood maps are typically not available or readily accessible. Working with provinces and territories, the national *Flood Hazard Identification and Mapping Program* will undertake flood hazard mapping in higher risk areas. Flood hazard maps are a key input to effective land use planning and adaptation efforts. Flood risks should also, as a rule, be disclosed to would-be homebuyers. This is not mandatory in Canada (Public Safety Canada, 2022[140]). Most households in high-risk areas are unaware of their flood risk (Public Safety Canada, 2022[140]). Better flood hazard maps and communication of flood risks will help protect Canadians and reduce overall risk exposure.

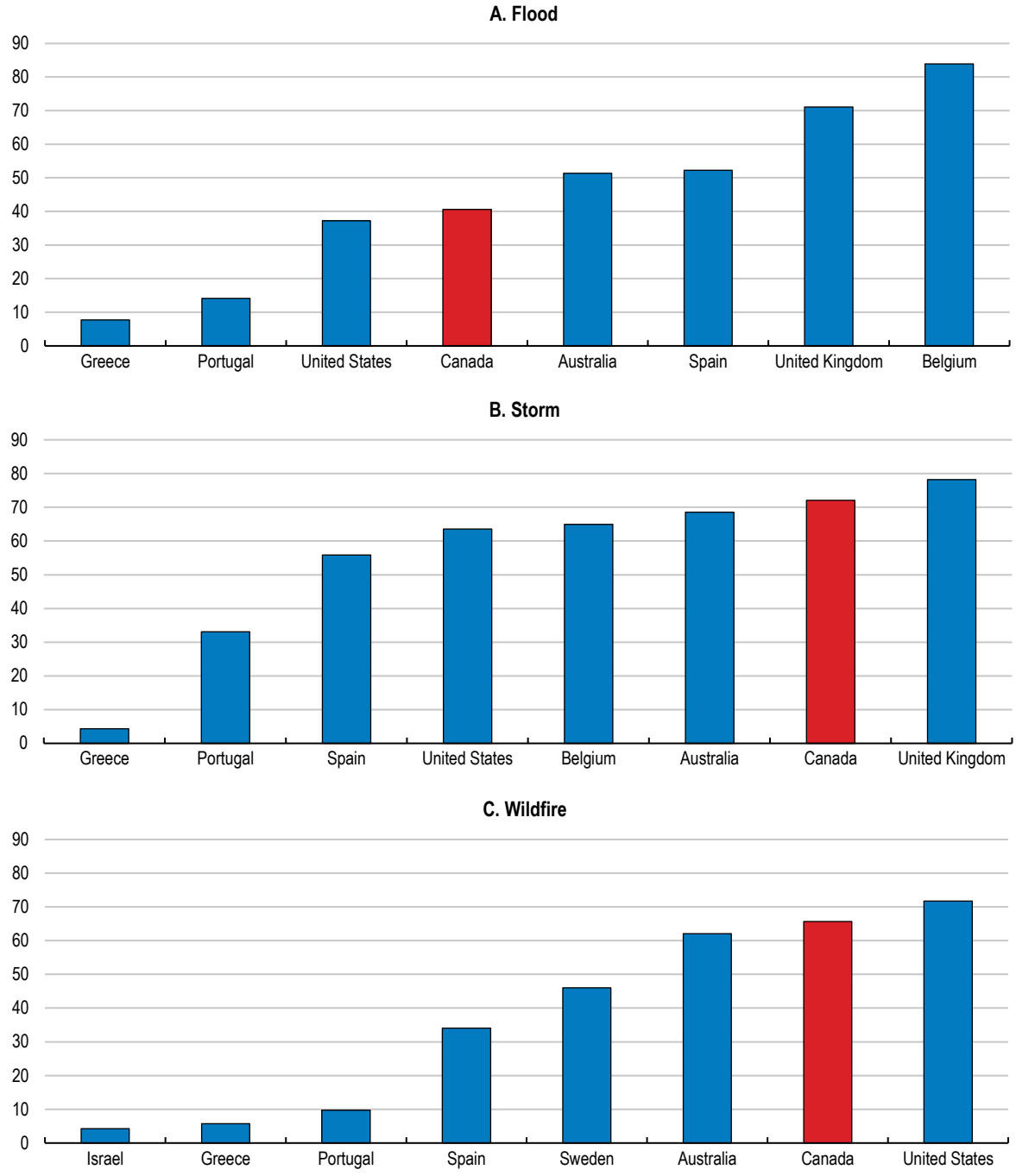
Closing gaps in flood insurance

Better quantification of flood hazards can also help close gaps in markets for flood insurance (OECD, 2016[139]). Flood insurance is not mandatory in Canada and was only introduced by the insurance industry in 2015 (Public Safety Canada, 2020[141]). The cost of insuring buildings in flood-prone areas tends to be prohibitive. A 2022 government review found that risk-based premiums in high-risk areas could cost up to CAD 15 000 just for flood endorsements, adding to other costs of insuring homes (Public Safety Canada, 2022[140]). With the highest-risk households uninsured, governments step in with disaster relief when catastrophic events occur. Payments under Canada's Disaster Financial Assistance Arrangements – the national programme that reimburses part of provinces and territories' disaster response and recovery costs – have increased in recent years (OECD, 2019[133]). In effect a form of subsidised insurance, public disaster relief can indirectly encourage ongoing risky land use. Alternative government interventions, addressing flood risks and inter-related climate hazards, can likely channel support to where it is needed at lower cost, while encouraging building in safer areas.

A flood insurance taskforce (Public Safety Canada, 2022[140]) recently confirmed that gaps in Canadian markets for flood insurance create inefficiencies. The taskforce examined approaches to flood insurance in other countries. Since many countries have faced similar problems (Figure 28), Canada can learn from solutions developed elsewhere (Box 19). Approaches that support broad coverage availability, leverage private market capacity and encourage risk reduction can avoid potential inefficiencies in purely public schemes for insuring against flood risks.

Figure 28. Insurance coverage for natural catastrophes is low in many OECD countries

Share of economic losses insured by type of risk, 2000 to 2019



Note: The chart shows the share of economic losses insured based on the midpoint of two estimates: the share of total losses that were insured, and the average of the share of insured losses across each individual event. Presenting the midpoint of the two estimates mitigates bias in the data from events with large total losses and low reported insured losses.
Source: OECD (2021[142]). The graph shows OECD calculations based on data provided by Swiss Re sigma and PCS. Reported economic losses are included only for events for which an insured loss estimate is also available.

StatLink 2 https://stat.link/pnix1a

Box 19. Approaches to flood insurance in other OECD countries

The **United States** federal government provides flood insurance through the National Flood Insurance Program (NFIP). While efforts are being made to incorporate risk-based premiums into NFIP policies and provide incentives for risk reduction and better land-use planning, many policyholders continue to benefit from subsidised insurance coverage. NFIP coverage is only available in communities that implement a defined set of floodplain management standards. This provides a mechanism for the federal government to influence flood risk management by subnational governments. The move to risk-based premiums and legislative changes recognising the equivalence of private flood insurance, where required for federally-backed mortgages, should in future increase the role of private insurance markets in assuming flood risks.

Private insurance plays a larger role in the United Kingdom and France. Both countries encourage take-up of disaster insurance. In **France**, private insurers must include insurance against flood risk in property insurance policies. Coverage is funded from a fixed share of all premiums, regardless of risk exposure. Insurers in turn benefit from government-backed reinsurance. This means taxpayers may absorb losses, although only if (reinsured) losses exceed the capacity of the state-backed reinsurer. By not reflecting flood risk in premiums, insurance in France is affordable for assets in vulnerable areas. In areas of moderate risk, where construction is still allowed, land use incentives may be distorted. This potential distortion is, however, at least partly addressed through the potential for increased deductibles to apply in places facing repeat losses, where communities have not developed risk prevention plans.

In the **United Kingdom**, property insurance policies include coverage for flood risks and banks often require those with mortgages to have flood coverage. Insurers are required to contribute to a reinsurance scheme called Flood Re through a levy on all residential property insurance policies. The reinsurer uses funds raised through the levy, and premiums collected for reinsurance coverage, to provide more affordable insurance for high-risk properties. Under the scheme, the cost of subsidising insurance premiums for high flood-risk properties falls partially on homeowners in lower-risk areas. If insurers pass on some of the cost of the Flood Re levy, overall costs of insurance for lower flood-risk properties are slightly more expensive than they otherwise would be. Coverage is available only for homes built before 2009, discouraging new development in high-risk areas. Flood Re aims to eventually exit the market (by 2039) by reducing risk among high-risk properties to levels where risk-based premiums for those properties would be affordable.

Source: OECD (2016[139]), CCR (2015[143]), Insurance Bureau of Canada (2019[144]), Public Safety Canada (2022[140]).

MAIN FINDINGS	RECOMMENDATIONS (key ones in bold)
Making carbon pricing more efficient	
Carbon pricing provides the core framework for cost-effective mitigation of GHG emissions in Canada. Planned higher prices levied on a larger share of emissions are needed to achieve Canada's ambitious climate targets. Benchmarks based on firms' own past emissions in large-emitter schemes provide less effective incentives than standards based on high-performing firms' emissions.	**Follow through with planned carbon price increases and annual tightening of emissions benchmarks in federal and provincial baseline-and-credit schemes.** **Expand emissions pricing to cover additional industries and types of greenhouse gases.** Consider requiring emission benchmarks in provincial baseline-and-credit schemes to be pegged to activity or product-based standards based on high-performing firms.
Redistribution of federal fuel charge revenues mitigates cost impacts on lower-income households while maintaining abatement incentives.	Continue to consider distributional impacts when designing climate policies.
Provinces set different limits on the use of offsets. Past limits have sometimes been too soft to maintain a uniform carbon pricing signal. Transparent information on credit prices is not available in all provincial systems. Increased carbon credit trade between provinces would make carbon pricing more efficient.	Introduce centralised tracking of data on supply and prices of credits in provincial schemes. Encourage credit trade between compatible emissions trading schemes.
Uncertainty around future carbon prices weakens incentives for green investments critical to decarbonise heavy industry.	Proceed with planned measures to reduce uncertainty around future carbon prices for major green investments.
Greater alignment of carbon mitigation approaches across countries could help scale up global abatement action and mitigate competitiveness effects in countries including Canada with increasingly stringent climate policies.	Continue to promote international cooperation and knowledge sharing on mitigation policies.
Addressing market barriers to greener electricity	
Large investments in grids and storage will be needed to meet new power demand and handle more renewable electricity. Proposed new clean electricity regulations would accelerate progress to zero-carbon grids, but likely at a higher cost than carbon pricing could achieve in competitive power markets. Increased electricity trade could aid transitions to market-based pricing and lower costs of storing intermittent energy. Limited interties impede inter-provincial trade.	Follow through with proposed federal clean electricity regulations. **Plan for long-run transitions to market-based electricity pricing at the provincial level, aided by pooling production with other provinces and federal infrastructure investment to support intertie development.** Support grid integration in Atlantic Canada.
Approval processes for renewable energy developments can deter important investments.	Avoid using bans on offshore wind power and simplify review processes. Provide data to help provinces identify land suitable for renewable energy developments and pre-approve land for such use.
Without government support, employment and income losses from the rapid phase-out of coal-fired power may be large in some communities.	Provinces should support workers displaced from jobs in fossil fuel industries with re-training and re-employment assistance while removing obstacles to geographical labour mobility.
Indigenous and remote Canadian communities face particular challenges in the green transition. A range of programmes are in place to facilitate mitigation and adaptation in off-grid communities.	Maintain support for green transition initiatives in Indigenous and remote communities while continuing to back Indigenous leadership in mitigation and adaptation measures.
Policies to moderate peak demand will be important to minimise generation capacity needed to accommodate new power demand.	**Introduce time-of-use electricity pricing as a default option for residential customers in provincial electricity markets, supported by smart meters.**
Ensuring deep emissions reductions from the oil and gas industry	
Methane regulations are keeping Canada on track to drive down methane emissions from oil and gas production.	Continue work to improve estimation and tracking of methane emissions, with a view to incorporating methane in carbon pricing mechanisms.
Carbon costs facing oil sands producers are too low to achieve federal greenhouse gas emission targets.	**Focus on strengthening price signals for decarbonisation of oil and gas extraction using existing federal and provincial carbon pricing systems.**
Overlapping credit schemes, grants and tax support for carbon capture utilisation and storage risk over rewarding carbon capture investments as technologies improve.	**Continue support for carbon capture and storage investments while consolidating subsidies, as planned, when technology improvements permit.**
Reducing emissions from road transport	
New Clean Fuel Regulations can help grow a domestic biofuel market and reduce road transport emissions. Rules guarding against induced land use change emissions may be challenging to enforce.	Review the Clean Fuel Regulations to ensure they produce expected results and do not have unintended consequences.
Governments are supporting electric vehicle uptake through supply and demand-side measures. Support is useful while markets are still maturing.	Maintain support for EV charging infrastructure while EV markets are still maturing. Rein in electric vehicle support, including purchase grants and tax incentives, as markets for electric vehicles become more established.

MAIN FINDINGS	RECOMMENDATIONS (key ones in bold)
Reducing emissions from road transport	
Policies to reduce car use and support active transport and public transport would have benefits beyond emission reduction.	**Provinces should increase use of road user charging and pare back constraints on new supply of housing in urban areas to improve the viability of efficient and accessible public transport.**
Technological solutions for decarbonising road freight are still maturing. It is likely that more than one solution will be needed.	Continue to work with the United States to tighten emissions standards for light and heavy-duty vehicles. Support charging and refuelling infrastructure along highly-trafficked routes. Sponsor pilot studies to test truck technologies in Canadian conditions.
Encouraging energy-efficient and low-carbon buildings	
National model energy codes for buildings continue to tighten. But slow provincial adoption of the code risks large retrofitting costs later on.	**Encourage fast provincial adoption of the latest energy code with federal support for capacity building.**
Most provinces do not have plans to ban oil heating. Canada is moving more slowly than leading OECD countries to phase out emission-intensive heating systems.	Move quickly to ban installation of oil heating systems in homes while maintaining means-tested support for replacing oil heating with clean, energy-efficient alternatives.
Retrofitting schemes can accelerate building energy improvements but risk disproportionately benefiting well-off households. Better information on buildings' energy performance can improve incentives to upgrade low-performing homes and service-industry buildings.	**Expand and re-target retrofitting grants towards middle and lower-income households.** Expand building certification schemes.
Canada has started to put together a strategy for reducing emissions embodied in building materials.	Identify and remove regulatory barriers to greater use of low-carbon building materials and products.
Limiting the costs of climate change	
Canada's climate is changing already. Flooding is the most common and costly natural disaster in Canada, with high-risk properties often uninsured and buyers unaware of their flood risk.	**Improve flood maps and communication of flood risks while integrating climate-related risks in land-use planning.** **Consider introducing measures to support the availability and take-up of affordable flood insurance.**

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