IMF Country Report No. 23/35

CHILE

January 2023

TECHNICAL ASSISTANCE REPORT – AN EVALUATION OF IMPROVED GREEN TAX OPTIONS

This Technical Assistance Report on Chile was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed in November 2022.

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Chile

An Evaluation of Improved Green Tax Options

Diego Mesa Puyo and Karlygash Zhunussova

Technical Report

November 2022

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ABBREVIATIONS AND ACRONYNMS

BAU	Business As Usual
BBL	Barrel
CO_2	Carbon Dioxide
COP26	Glasgow Climate Conference
CPAT	Climate Policy Assessment Tool
EITE	Energy-Intensive, Trade-Exposed
ENAP	Empresa Nacional del Petróleo
ETS	Emissions Trading System
FAD	Fiscal Affairs Department
GDP	Gross Domestic Product
GJ	Gigajoule
GHG	Greenhouse Gas
IEA	International Energy Agency
ICPF	International Carbon Price Floor
IPCC	UN Intergovernmental Panel on Climate Change
KW	Kilowatt
kW/h	Kilowatt hour
LIT	Liter
LULUCF	Land Use and Land Use Change and Forestry
MEPCO	Mecanismo de Estabilización de Precio de Combustibles
$MtCO_2eq$	Million Tons of CO2 equivalent
MW	Megawatts
NDC	Nationally Determined Contribution
NOx	Nitrogen Oxide
OECD	Organization for Economic Co-Operation and Development
$PM_{2.5}$	Particulate Matter that a diameter less than 2.5 micrometers
PPAs	Power Purchase Agreements
SII	Servicio Interno de Impuestos
SMA	Superintendency of the Environment
SO_2	Sulphur Dioxide
SCC	Social Cost of Carbon
TGR	General Treasury
UNFCCC	United Nations Framework Convention on Climate Change
WHD	Western Hemisphere Department

PREFACE

At the request of the Chilean Minister of Finance, a team from the IMF Fiscal Affairs Department (FAD) visited Santiago between October 3-7, 2022, to evaluate options to expand the existing direct carbon tax in Chile. The mission comprised Diego Mesa Puyo (head) and Karlygash Zhunussova, both from FAD's Climate Policy Division.

The mission met with the Minister of Finance, Hon. Mario Marcel Cullell, the Minister of Environment, Hon. María Heloisa Rojas Corradi, and the Minister of Energy, Hon. Diego Pardow Lorenzo. The team also had fruitful discussions with a range of government officials. In the Ministry of Finance, the mission met with Mrs. Claudia Sanhueza Riveros, Deputy Minister, Mr. Nicolas Bohme, Tax Policy Coordinator, and Mrs. Camila Schmidlin and Mr. Jose Alvarado from the Tax Policy Group; in the Servicio de Impuestos Internos (SII) meetings were held with Carolina Saravia, Deputy Director of Enforcement; in the Ministry of Environment discussions were held with Mr. Rodrigo Barragan and Mrs. Isabel Rojas from the Environmental Economy Division; in the Ministry of Energy, the mission met with Mr. Juan Pedro Searle, Chief of the Climate Change Division; in the National Commission of Energy, the mission met with Mr. Marco Antonio Mancilla Ayancán and technical staff; in the Environmental Superintendency, the mission met with Mr. Emanuel Ibarra Soto, Superintendent, and technical staff. In the private sector, the mission had meetings with Mr. Camilo Charme, General Manager, and Mr. Claudio Muñoz, Head of Studies, at Generadoras de Chile (the main power sector business group); and with Mr. Jorge Cáceres, Director of the Centre of Environment and Energy at Sociedad de Fomento Fabril (Association of Industrial Promotion). The mission also met with Mr. Adrien Vogt-Schilb, Senior Economist of the Climate Change and Sustainability Division of the Inter-American Development Bank, Chile Office; and with Mr. Luis Gonzales, head of Climate Change, Energy and Environmental Economics at Universidad Católica de Chile.

The mission held a workshop to present the Climate Policy Assessment Tool (CPAT) to more than 15 staff from the Ministry of Finance, Ministry of Energy, Ministry of Environment, SMA, SII and the Central Bank of Chile.

The mission acknowledges the excellent interpretation services provided by Mrs. Gina Cabach, Mrs. Claudia Goet and Mr. Pedro Velloso during meetings and the workshop.

Finally, the mission would like to express its gratitude for the outstanding support and hospitality received from the Ministry of Finance staff, in particular Mr. Nicolas Bohme, Mrs. Camila Schmidlin and Mrs. Vanessa Paluba.

EXECUTIVE SUMMARY

Chile is committed to climate action and is recognized as a regional leader in the fight against global warming. Over the past eight years, Chile has made important climate commitments, such as updating its Nationally Determined Contribution (NDC) to reduce carbon dioxide (CO_2) emissions by 30 to 45 percent in 2030 from 2016 levels and reach carbon neutrality before 2050.

Consistent with its emission reduction ambitions, Chile has developed multiple climate policies. In 2014, it became the first Latin-American country to introduce green taxes on CO_2 emissions and local pollutants, as well as on new passenger cars based on fuel efficiency and emissions. In 2019, Chile also became the first country in the region to issue green bonds, publish a financial strategy for climate change, and announce the decommissioning of coal-fired power plants by 2040. In June 2022, Congress approved the Framework Law on Climate Change, making carbon neutrality legally binding, and introducing new mitigation tools and institutional arrangements.

While Chile has made important progress to align policies with climate commitments, additional mitigation efforts are required to reach emission reduction targets in 2030 and by midcentury. The Ministry of Finance announced that improvements to green taxes will be included in the general tax reform presented to parliament in July 2022. Moreover, since the country has five years of experience administering green taxes, further carbon pricing enhancements should leverage existing institutional capacity without adding significant administrative burden.

This report evaluates existing green taxes in the country, including revenue performance, coverage, and selected design issues. It also discusses changes that will take effect in 2023, as well as new mitigation tools introduced in the Framework Law on Climate Change. The report uses the Climate Policy Assessment Tool (CPAT) to evaluate different scenarios to improve carbon pricing and bring the country closer to or in line with its climate targets. Results are presented in terms of emissions reduction, revenue raising potential, effects on GDP and energy prices, distributional impacts across households and firms, abatement costs and co-benefits. The report also offers different options to recycle revenue from higher carbon pricing to help the government prepare a well-thought-out reform communication strategy.

At $5 per ton of CO_2, the green tax on carbon emission from stationary sources is low by international standards and significantly lower than the $32.5 per ton of CO_2 social cost of carbon estimated by the government.[1] Moreover, simulations done by the mission show that the tax coverage needs to be broadened and the rate increased to achieve the country climate goals. Strengthening the carbon tax should be a gradual process, however, especially considering the global increase in energy prices observed in 2021 and the first half of 2022. The recent fall in

[1] The recent RFF estimate on social cost of carbon is $185 per ton of CO_2. See Rennert and others (2022)

fossil fuel prices,[2] however, may give the government an opportunity to lock-in a higher carbon tax without increasing energy prices relative to recently observed levels. As for local emissions, Chile is a pioneer in levying taxes on local air pollutants such as particular matter ($PM_{2.5}$), nitrogen oxide (NOx), and sulphur dioxide (SO_2), which directly affect communities in areas where emitter industries are located.

Before increasing the tax rate and coverage, design issues that create economic distortions in the power sector should be corrected. First, the full amount of the carbon tax should be included in the variable cost of all generation plants considered for the economic dispatch. This change would allow the economic dispatch to effectively differentiate between plants with higher emissions and higher costs due to the carbon tax, and more competitive power plants with lower or zero emissions. Moreover, once that correction is made, the cross subsidy from utilities to marginal or inframarginal fossil fuel-based power plants should automatically disappear.

The green tax on mobile sources has a very narrow coverage and includes multiple exemptions. This is problematic because the transport sector is one of the main emitters in the country. Moreover, excises and other fuel taxes in Chile have multiple distortions and have been found to be highly inefficient. For example, taxes on diesel have a complex set of credits and exemptions, and much lower rates than on gasoline. As a result, Chile consumes almost double the amount of diesel than the regional average on a per capita basis. This distortion could be corrected either by gradually bringing the excise rate on diesel on par with the one on gasoline, or by including the transport sector in the improved carbon pricing options modeled in this analysis. A feebate (not discussed in detail in this report) can also be considered to promote decarbonization of the vehicle fleet in case higher fuel taxes becomes too contentious.

Based on discussions with the authorities regarding the feasibility of carbon pricing improvements within the current tax reform proposal, the mission presents four different scenarios that would bring Chile closer or in line with its Nationally Determined Contribution (NDC) for 2030, and the legally binding net-zero pledge for 2050. Under the base and social cost of carbon (SCC) cases, Chile would achieve is NDC target by 2030 and be on track to reach net-zero by 2050. Under the moderate and hybrid scenarios, the county will be within 11 and 12 percent of achieving its NDC. It is important to note, however, that additional measures under all scenarios considered here, such as improved energy efficiency policies, introduction of feebates schemes or faster adoption of low and zero emission sources for transport, power, and industry, would further contribute to achieve climate goals. Below are the main assumptions under each scenario.

- **Moderate**: set the carbon tax at $15 per ton of CO_2 in 2025, increasing linearly to $50 per ton of CO_2 in 2035 but exempting the road transportation sector.

[2] Expressed in USD. The prices are still relatively high in local currency due to depreciation of the exchange rate.

- **Base case**: set the carbon tax at $15 per ton of CO_2 in 2024, increasing linearly to $60 per ton of CO_2 in 2030. The carbon tax excludes gasoline and diesel, but the excise on diesel is increased to bring the effective carbon rate equal to that of gasoline (starts from $0.05/liter in 2024 and increases linearly to $0.37/liter in 2030).
- **Hybrid**: consists of two parts.
    - Carbon tax applies only to the power sector, starting from $5 per ton of CO_2 (current level) in 2024 and increases at a lower slope at the beginning, up to $11 per ton of CO_2 in 2027. It then increases with a steeper slope up to $60 per ton of CO_2 in 2035.
    - Emissions Trading System (ETS) in the industrial sector, starting from $5 per ton of CO_2 (current level) in 2024, increasing at a lower slope at the beginning, up to $11 per ton of CO_2 in 2027. It then increases with a higher slope up to $60 per ton of CO_2 in 2035.
- **Social cost of carbon (SCC)**: economy-wide carbon tax starting from $35 per ton of CO_2 in 2024 and increasing linearly to $75 per ton of CO_2 in 2030.

The following table summarizes the results for each scenario in 2030 in terms of emissions reduction, revenue raising potential, GDP and energy prices, distributional impacts among households, abetment costs and co-benefits.

Scenario	Base	Moderate	SCC	Hybrid
Energy-related CO_2 emissions reduction in 2030, % to a BAU	17%	7%	16%	6%
Cumulative CO_2 emissions reductions in 2024-2030, MtCO2	51	20	59	17
Additional fiscal revenues raised in 2030, % of GDP	1.61	0.81	1.55	0.92
Cumulative additional fiscal revenues raised in 2024-2030, bn USD	25.3	7.4	29.1	12.3
Impact on GDP growth in 2030, percentage points deviation from the BAU growth	-0.09%	-0.08%	-0.06%	-0.08%
Residential electricity price increase in 2030, percent from the BAU price	24%	22%	25%	22%
Residential electricity price increase in 2030, percent from the current price	-4%	-6%	-3%	-5%
Industrial electricity price increase in 2030, percent from the BAU price	27%	24%	28%	24%
Industrial electricity price increase in 2030, percent from the current price	-19%	-20%	-17%	-20%

Relative mean consumption effect on the poorest after revenue recycling[3], % of BAU consumption	11.9	5.9	11.7	4.5
Pure abatement costs, % of GDP	0.35	0.07	0.32	0.06
Domestic co-benefits (transport, air pollution, climate), % of GDP	0.62	0.24	0.57	0.15

[3] Using 30 percent of revenues to compensate four bottom income deciles overcompensates the poorest

I. INTRODUCTION

1. **The Chilean authorities requested the IMF Fiscal Affairs Department (FAD) to evaluate options for improving green taxes and in particular the direct tax on carbon dioxide (CO_2) emissions.** This report assesses different scenarios to gradually increase the existing carbon tax and bring the country closer to or in line with its Nationally Determined Contribution (NDC) for 2030, and the legally binding net-zero pledge for 2050. The authorities expect the carbon tax to continue to be a central piece of Chile's green taxes package introduced in 2014, even if reviews are done periodically to ensure the country's climate objectives are met.

2. **A higher carbon tax is part of a broader tax reform the government is currently debating in Congress.** The proposed reform is ambitious, targeting net gains of 3.5 percent of GDP by 2026 to finance additional social spending. The reform also aims to make the tax system more progressive, simplify and lower compliance costs, and promote a greener economy. The authorities have not published an official revenue target for the carbon tax, but they informed the mission that corrective taxes, which combine green, health and territorial taxes, could raise, according to preliminary estimates, up to 0.5 percent of GDP.

3. **While Chile is committed to climate action, including a comprehensive institutional framework, multiple policy tools and setting specific emission reduction targets, the carbon tax needs to be strengthened to meet climate objectives.** In 2014, Chile became the first Latin-American country to introduce green taxes on both carbon emissions and local pollutants, as well as on sales of new light-duty vehicles based on fuel efficiency and nitrogen oxides (NO_x) emissions. In 2019, Chile was also the first country in Latin America to issue green bonds and to announce the decommissioning of coal-fired power plants by 2040. In addition, the financial strategy for climate change published in December 2019 aims to develop a framework for measuring green components in the budget and capacity building for green finance in the private sector. Moreover, in April 2020 Chile presented an updated NDC to the United Nations Framework Convention on Climate Change (UNFCCC) with emissions peaking in 2025 and reaching 95 million tons of CO_2 equivalent ($MtCO_2eq$) by 2030 (i.e., a 30 to 45 percent reduction from 2016 levels). Finally, in June 2022 the country published the Framework Law on Climate Change, which, makes carbon neutrality legally binding by 2050. However, at $5 per ton of CO_2eq, the existing carbon tax remains low and needs to be significantly increased to achieve the country climate and fiscal goals.

4. **Strengthening the carbon tax should be a gradual process, however, especially considering the global increase in energy prices observed in 2021 and first half of 2022.** Fossil fuel prices increased sharply during 2021 and the first half of 2022, largely as a result of the war in Ukraine, resulting in higher prices of electricity and refined products for households and firms in many jurisdictions. Although prices have retreated somewhat recently, energy prices continue to be well-above pre-pandemic levels. The expected fall in fossil fuel prices may give the government an opportunity to lock-in a higher carbon tax without increasing energy prices relative to recently observed levels. In any case, well targeted assistance to low-income households and energy-intensive or trade exposed sectors may be needed.

5. This report builds on ongoing work done by FAD and the Western Hemisphere Department (WHD) and uses the Climate Policy Assessment Tool (CPAT) developed jointly by IMF and World Bank staff. CPAT projects fuel use and CO_2 emissions by major energy sectors in Chile, including a model of investment and dispatch in the power sector, and assumptions about the price responsiveness of electricity demand and fuel use in other sectors that are representative of the broader climate modelling literature. The analysis also discusses international mitigation practices, while assessing different scenarios to gradually strengthen the existing carbon tax. Each scenario includes the tax effects on GDP and fiscal revenue, energy consumption and emissions reduction, distributional impact and incidence on households and firms, as well as other domestic environmental co-benefits. The scenarios are intended to bring emissions in Chile close to or in line with its NDC by 2030 and the carbon neutrality commitment by midcentury. Separately, the mission also discusses other alternative mitigation instruments and revenue recycling options that could be used to complement green taxes.

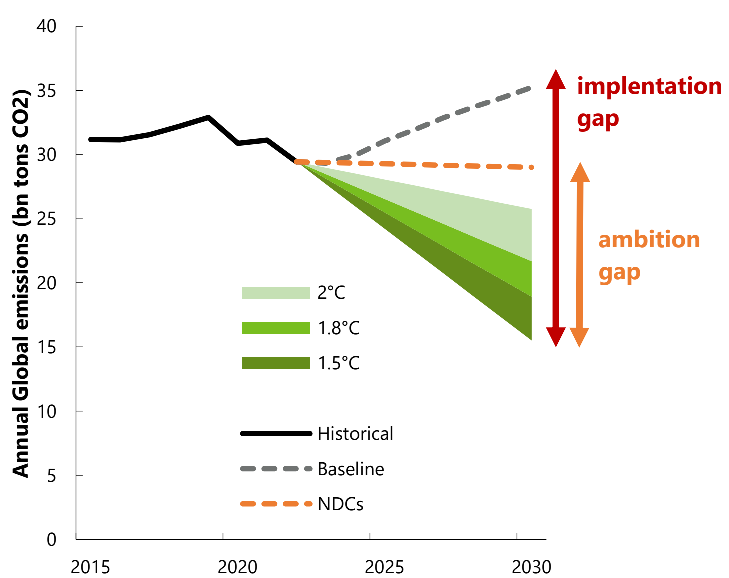
6. The report is structured as follows: Chapter II provides an overview of the current state of emissions globally, as well as energy prices, and emissions trends and targets in Chile; Chapter III reviews existing green taxes and evaluates their performance and selected design issues; Chapter IV presents different scenarios to expand the carbon tax in Chile using the CPAT methodology; Finally, Chapter V discusses options for revenue recycling.

II. OVERVIEW OF EMISSIONS, TRENDS AND TARGETS

A. Global Context

7. **Maintaining the 1.5°C target alive—the main goal of the 2015 Paris Agreement—requires additional efforts as the world battles an energy price crisis in the wake of the post COVID-19 economic recovery.** Global CO_2 projections and pathways to achieve climate targets suggest that CO_2 and other greenhouse gas (GHG) emissions must be cut by 50 to 25 percent, respectively, below 2019 levels by 2030. This reduction should be followed by a transition to net zero emissions or negative net emissions to limit global warning to 1.5 – 2.0ºC. With existing policies, however, the base case projections imply that global CO_2 emissions will rise from 30 billion tons in 2020 to about 37 billion by 2030, while containing global warming to 1.5 – 2.0°C above pre-industrial levels requires CO_2 emissions to be limited to about 15 to 25 billion tons in 2030 (see Figure 1). If action is not taken soon at a global scale, the window of opportunity for containing global warming will close. In addition, the global energy crisis may exert additional pressure on emission reduction efforts in the near-term, as some countries have reverted to fossil fuel power generation to guarantee energy supply.

Figure 1. CO_2 Emission and Global Pathways



Source: IMF staff using CPAT and IPCC (2022).

8. **The number of countries pledging to achieve net-zero emissions by 2050 has continued to increase in recent years.** Leading up to the Glasgow climate conference (COP26)

in November 2021, several countries updated their NDCs as part of the first five-yearly iteration of the Paris Agreement's "ratchet mechanism". According to the UNFCCC, as of October 12, 2021, there were 116 new or updated NDCs, and a total of 165 NDCs representing all 192 parties to the Agreement and covering 94.1 per cent of total global emissions in 2019. These emissions are estimated at 52.4 Gt CO_2 eq excluding land use and land use change and forestry (LULUCF).[4] More than 70 countries, which account for 76 percent of global emissions, have committed to net-zero emissions by midcentury[5], including most of the largest emitters such as Canada, the European Union, Japan, Korea, the United Kingdom, the United States (all 2050), and China (2060).

9. At an aggregate level, however, updated commitments remain insufficient and more ambitious near-term targets and policy action are needed to limit global warming. According to the UN, current national climate plans – for all 193 Parties to the Paris Agreement taken together – would lead to a sizable increase of almost 14% in global GHG by 2030, compared to 2010 levels.[6] There is an urgent need to match near-term ambition with credible policy action, as the updated NDCs remain insufficient to meet the Paris target of limiting global warming to "well below 2°C". Moreover, many countries have stated their 2030 emission goals in terms of percentage reductions or absolute emissions targets by 2030 but few have provided details on how to achieve those objectives. In addition, even if countries further tighten their 2030 pledges, there is no automatic mechanism ensuring commitments are achieved.

10. A 2021 report by the UN Intergovernmental Panel on Climate Change (IPCC)[7] stated that global warming of 1.2ºC is caused by man-made factors and warming is happening faster than previously projected. The raise in temperatures is also causing a wide range of disruptive climate-related impacts, including heatwaves, droughts, floods, hurricanes, and higher sea levels. The frequency and severity of these phenomena are likely to intensify as temperatures continue to raise. Moreover, a 2018 IPCC report[8] had already warned that the risk of tipping points in the global climate system (e.g., runaway warming from release of underground methane, collapse of major ice sheets, shutting down of ocean circulatory systems, destruction of the natural world) is likely to increase exponentially with warming above 1.5ºC.

11. Against this background, the IMF has proposed an international carbon price floor (ICPF) with a realistic prospect of catalyzing the needed global action in the next decade.[9]

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[4] See "*Update of the Key Findings of the NDC Synthesis Report - published 25 October 2021*" https://unfccc.int/documents/307628

[5] See https://www.un.org/en/climatechange/net-zero-coalition

[6] Ibid

[7] IPCC, 2021. AR6 Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change, Geneva, Switzerland. Available at: www.ipcc.ch/report/ar6/wg1

[8] IPCC, 2018. Global warming of 1.5°C. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

[9] See *"Proposal for an International Carbon Price Floor among Large Emitters IMF Staff Climate Notes 2021/001"*

The ICPF has four key components: (i) it would be negotiated between a small number of key large emitting countries, (ii) negotiation would focus on the minimum carbon price that each must put on their CO_2 emissions, (iii) it would address equity concerns through differentiated price floors and transfers, and (iv) accommodate other policies with equivalent emissions impacts as minimum price floor requirements. Ratcheting up ambition among a smaller group of countries, especially the large emitters, would be more straightforward than a global agreement, and regional carbon price floors would also be a possibility. For example, several countries in Latin American have implemented carbon taxes at modest levels (e.g., Argentina, Chile, Colombia, Mexico) and several countries in Asia and Pacific have implemented or are considering carbon pricing (e.g., China, Japan, Korea, Philippines, Singapore, Vietnam). Regional carbon price floor arrangements could facilitate a scaling up of these country level initiatives and provide valuable experience for developing a global price floor arrangement. Moreover, the prospect of a regional agreement may also encourage individual countries to align their carbon pricing mechanism with the regional or ICPF level.

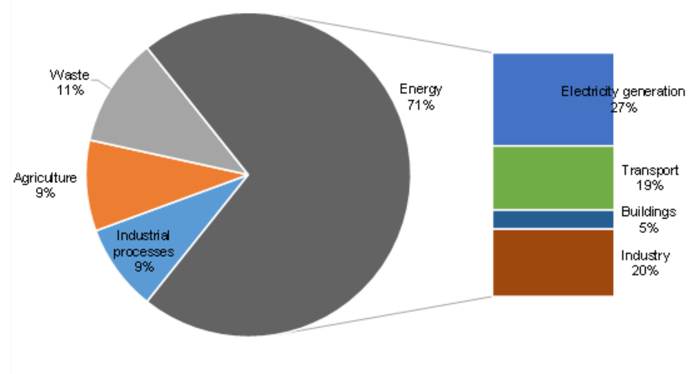
12. IMF analytical work also suggests that additional measures equivalent to a global carbon price exceeding $75 per ton by 2030 are needed to limit global warming below 2C.[10] This is especially true for large emitters. G20 countries should adopt measures equivalent to a carbon price of over $75 per ton by 2030, on top of existing policies, to cut emissions at least 30 percent below business as usual (BAU) levels.

B. Emissions in Chile

13. Energy-related emissions accounted for 71 percent of Chile's 120 $MtCO_2$ GHG emissions in 2020, excluding LULUCF emissions. The largest polluting sector in Chile is power generation (27%), followed by industry (20%), transport (19%), waste (11%), agriculture and industrial processes (each 9%), and buildings (5%). LULUCF emissions were estimated at negative 58 $MtCO_2eq$, although measurement is less accurate and more contentious than for energy-related ones.

[10] See *"Not Yet on Track to Net Zero: The Urgent Need for Greater Ambition and Policy Action to Achieve Paris Temperature Goals"*

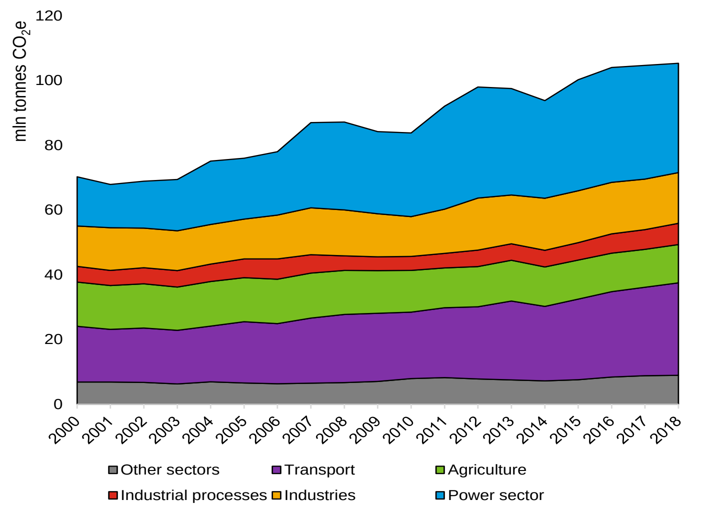
Figure 2. GHG Emissions in 2020 by Source



Source: IMF/EDGAR/FAO/UNFCCC

14. **GHG emissions excluding LULUCF in Chile grew 50 percent between 2000 and 2018.** Most of the emissions growth comes from the power generation, which grew by 122 percent between 2000 and 2018 period, and transport which grew by 66 percent in the period. Industry and industrial processes emissions together increased by 29 percent in the same period, while agricultural emissions decreased by 14 percent.

Figure 3. Historical GHG Emissions, 2000-2018

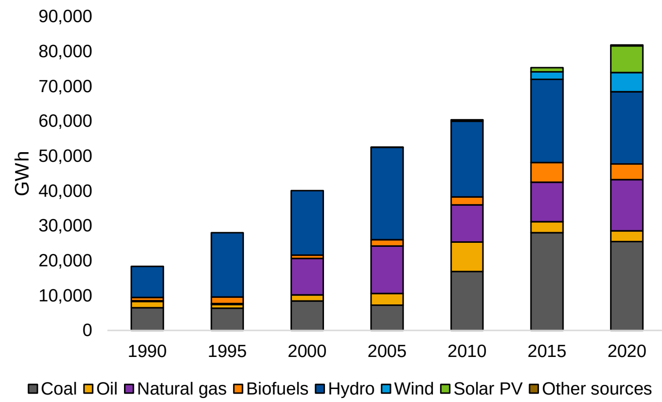


Source: Ministerio del Medio Ambiente

15. **In the power sector, fossil fuels accounted for 53 percent of electricity generation in 2020, decreasing from 60 percent in 2010.** However, in absolute terms, generation from fossil fuels increased by 20 percent, from 36 TWh to 43 TWh. Generation shares for coal, gas, and oil were 31, 18, and 4 percent respectively in 2020. Hydro power accounted for a quarter of electricity output, and solar and wind power reached 9 and 7 percent, respectively. Chile has successfully promoted an expansion of the power generating capacity with the incorporation of

variable renewable energy over the past 10 years, increasing the share of solar and wind energy from zero to 16 percent.

Figure 4. Electricity Generation by Source, 1990-2020



Source: IEA

C. Energy Prices in Chile

16. Effective carbon pricing via excises in Chile does apply to transport sector fuels, albeit at comparative low levels and with multiple distortions. While Table 1 shows that the effective tax rate[11] in the transport sector is higher than in other sectors, there is a significant difference between the tax rates for gasoline and diesel. Gasoline's effective rate is $200 per ton of CO2, while diesel's effective rate is more than three times lower.

Table 1. Effective Carbon Rates in Chile, 2020

	Power			**Industry**			**Transport**			**Buildings**
Sector/fuel type	Coal	Natural gas	Other fossil fuels	Coal	Natural gas	Other fossil fuels	Gasoline	Diesel	Other products	Other fossil fuels
Share in CO2 emissions, %	32%	7%	2%	3%	5%	12%	11%	16%	3%	9%
Effective fuel tax, $/tCO2	5.2	5.2	21.8	5.2	5.2	46.4	200.7	58.9	9.0	53.3

Source: IMF staff calculations

17. Gasoline and diesel's effective carbon tax rates are among the lowest in the OECD (see Figure 5). The effective carbon tax rate for gasoline in Chile is higher only than a handful of countries, remaining as one of the lowest in the OECD. The effective carbon tax rate on diesel is even lower, just ahead of Costa-Rica and Colombia.

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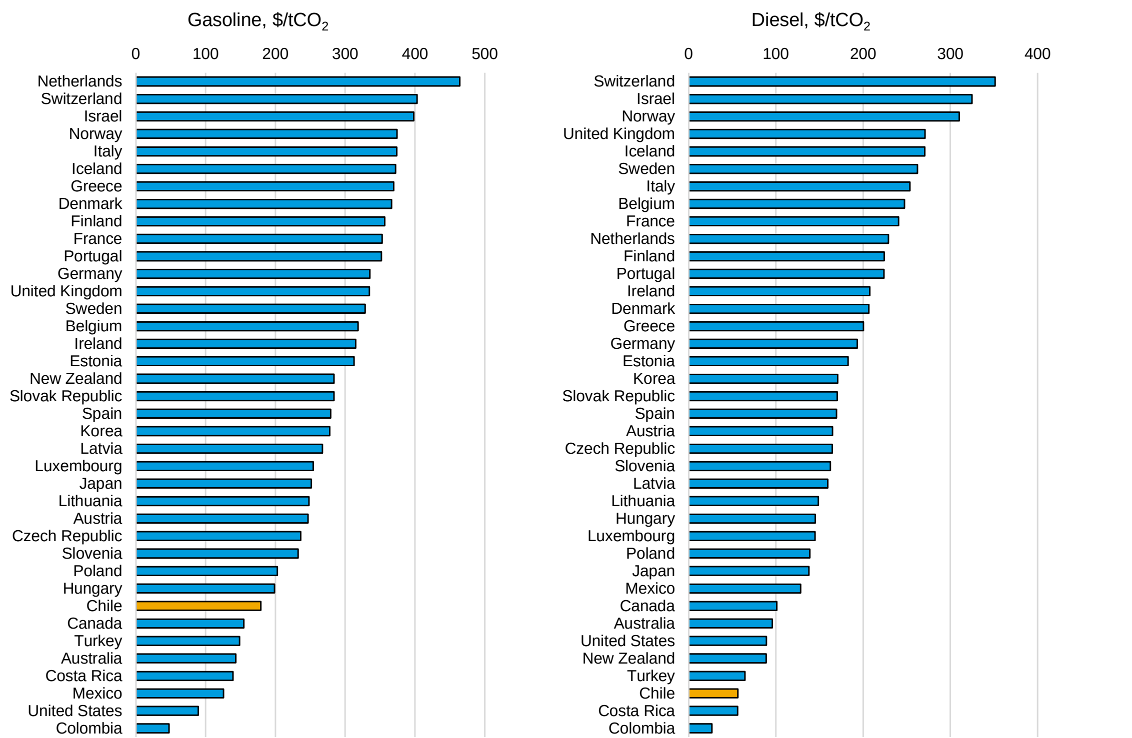
[11] The coverage of the existing carbon tax is 29.4% and is expected to increase to 40% after recent changes in legislation

Figure 5. Effective Carbon Rates for Gasoline and Diesel in 2020, OECD

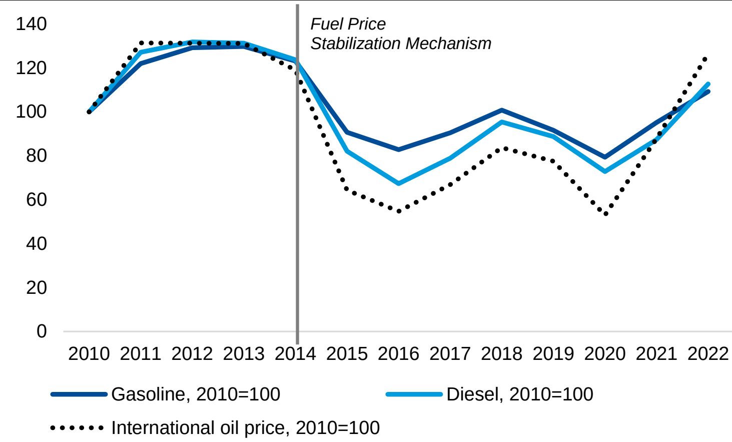


Source: IMF staff calculations.

Note: Assumed global emission factors for gasoline and diesel, the estimates may vary for Chile calculations

18. The Fuel Price Stabilization Mechanism (MEPCO) limits domestic price fluctuations on gasoline and diesel despite changes in international fuel prices. Effectively, the taxation on diesel and gasoline changes depending on international oil prices and the exchange rate, and in some cases, it can turn into a negative tax (subsidy). Since 2014, the year when MEPCO started to operate in its actual form, changes in retail gasoline and diesel prices have deviated from changes in international oil price (see Figure 6).

Figure 6. Historical Gasoline and Diesel Retail Prices vs International Oil Price

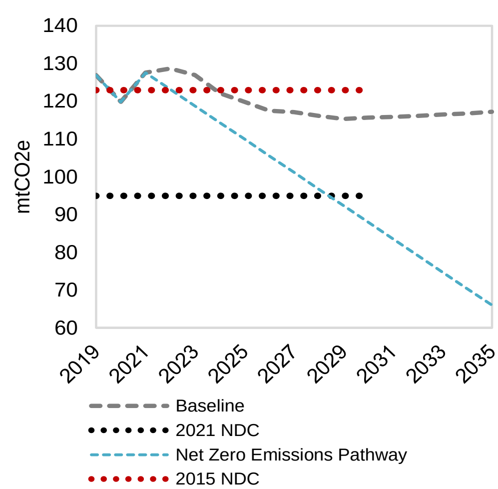


Source: IMF staff calculations

D. Emissions Targets in Chile

19. As a contribution to the Paris Agreement, Chile has pledged to reduce GHG emissions to 95 $MtCO_2eq$ by 2030 in its updated NDC. This is a significant increase in ambition compared to the first NDC submission, which pledged a reduction of emissions to 123 $MtCO_2eq$. The updated NDC commits to GHG budget not exceeding 1100 $MtCO_2eq$ in 2020-2030 with a peak in 2025. Additionally, Chile committed to reduce black carbon emissions by 25 percent in 2030 vs. 2016 levels. According to IMF staff projections, the 2015 NDC target would be reached in the baseline (i.e., it is unambitious), while the updated NDC target will require an 18 percent reduction in GHG emissions excluding LULUCF in 2030, relative to the baseline.

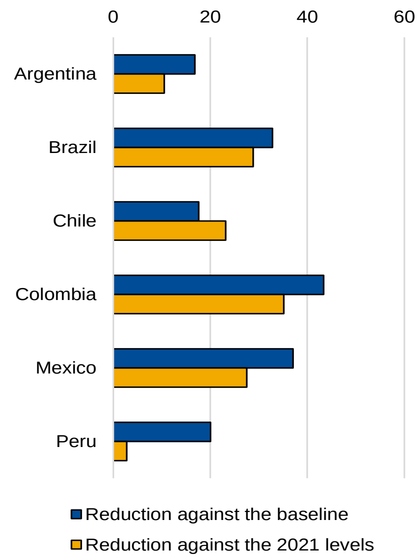
Figure 7. GHG Emissions vs Paris Pledge (NDC) and Net Zero Emissions Pathway



Source: IMF staff using CPAT

20. Compared to other LAC6 countries, Chile's new NDC is on par with other countries when expressed as a reduction to current levels, but less ambitious when shown as a reduction against the baseline. Chile's NDC implies an 18 percent reduction against the baseline in 2030. Reductions in other countries in the region vary from 17 percent in Argentina to 43 percent in Colombia. However, expressed as a reduction to current levels, the NDC implies 23 percent reduction from 2021 GHG emissions, which is in line with other LAC6 countries (variation from 3 percent in Peru to 35 percent in Colombia).

Figure 8. Average NDC Pledges in LAC6 Countries



Source: IMF staff using CPAT

21. Chile also has pledged to net-zero emissions by 2050, making this a legally binding commitment in the recently approved Framework Law on Climate Change. Chile was the first country in Latin America to pledge net-zero emissions in 2020. The target covers all sectors and gases and proposes separate emissions reduction and removal targets. The net-zero target became legally binding in the Framework Law on Climate Change (June 2022).

III. EVALUATION OF GREEN TAXES IN CHILE

A. Green Taxes, Legal and Institutional Framework

22. Chile passed a general tax law in 2014 that introduced green taxes on annual CO_2 emissions and local pollutants from stationary sources, as well as a tax on mobile sources.[12] The tax on stationary sources, as it is applied currently, has two components: a levy of US$5 per ton of CO_2 (i.e., a standard carbon tax) and a local pollution charge, which taxes air pollutants such as particulate matter ($PM_{2.5}$), nitrogen oxide (NOx) and Sulphur dioxide (SO_2) based on population and local pollution conditions. In the case mobile sources, the tax is a function of the vehicle's fuel economy, NOx and the vehicle price.

23. The direct carbon tax is currently levied on CO_2 emissions from stationary sources with a thermal capacity of 50 megawatts (MW) or higher. These include thermal plants for power generation, as well as emissions from boilers used in industrial processes in pulp and paper, fisheries, mining and other sectors. In the case of local pollutants, the tax is levied on the same entities subject to the direct carbon tax and is based on a formula that seeks to compensate environmental externalities borne by local communities. The tax on mobile sources only applies to light-duty vehicles and includes multiple exemptions.

24. Several institutions are involved in administering green taxes, including entities from the Ministry of Finance, Ministry of Environment and Ministry of Transport and Telecommunications. in the case of the tax on stationary sources, the Superintendency of the Environment (SMA) oversees the methodologies and the systems to monitor, verify and report the emissions subject to the tax. In the case of the tax on mobile sources, fuel economy and NOx are determined by the Ministry of Transport and Telecommunications according to the technical characteristics of each vehicle. The Ministry then provide the tax values for each vehicle to the Internal Revenue Service (SII). For both taxes, the SII receives the tax declaration of the companies or private agents subject to the tax, while the General Treasury (TGR) collects the payments. The institutional framework for both taxes and its operation are contained in Law 20,780/2014 and regulations, a measurement protocol published by SMA, a notification system managed by the Ministry of Environment and the Ministry of Transport, and both a registry and monitoring, reporting and verification system operated by SMA.

25. The tax on stationary sources were first implemented in 2017. According to the SII, in its first year of implementation the tax on stationary sources covered 58 taxpayers and raised $191 million, covering about 39 percent of total CO_2eq emissions in Chile. Most of the revenue came from CO_2 emissions (88 percent) followed by $PM_{2.5}$ (8.2 percent), NOx (3.1 percent), and

[12] See section 8 of Law 20.780 of 2014

SO_2 (0.9 percent).[13] In terms of sectors, power generation accounted for 53 percent of the revenue, followed by trade with 21 percent and construction with 12 percent. Five years since its introduction, revenue has decreased modestly although the composition has varied as a result of a cleaner power sector. In 2021, the tax collected $186 million from 56 taxpayers. Power generation accounted for 45.8 percent of the revenue, followed by trade with 31 percent, construction with 13.1 percent and transport with 4.7 percent.

26. In February 2020, the Congress passed a Tax Modernization Law[14] that will expand the tax base for green taxes on stationary sources. As of January 1st, 2023, the tax will no longer be levied based on installed thermal capacity, but on a threshold of emissions partially or totally released in combustion[15] processes. The tax will now apply to all stationary sources that annually emit 100 or more tons of $PM_{2.5}$, or 25,000 or more tons of CO_2. Emissions from hot water boilers for personal use and generation units with a capacity of less than 500 kilowatts (kw) are exempted from the tax, as well emissions released from raw materials used in the production processes (i.e., process emissions). Independent studies done in the country estimate that these changes will expand the tax coverage from 39 to 45 percent of CO_2eq emissions[16].

27. The Tax Modernization Law introduced a carbon offset mechanism that would allow companies to lower their carbon tax burden. Starting on February 24, 2023, carbon emissions may be offset through emission reduction projects developed in Chile (or in the municipality in the case of local pollutants) and following standards to be defined and published by the Ministry of the Environment. The law establishes three general criteria for the projects to be eligible for offsets. First, emission reductions must be additional to any environmental or sector regulation that the taxpayer is subject to. Second, the reduction in emissions should be measurable and verifiable by the Ministry of Environment. Finally, emission reductions projects should operate throughout the time that the taxpayer is liable to the green tax. At the time of the mission, however, the Ministry of Environment has not issued the regulation for the offset mechanism.

28. The Framework Law for Climate Change approved in June 2022 introduced emission standards and tradable carbon credits (i.e., the basis for an Emissions Trading System (ETS)). The Law provides for the Ministry of Environment to establish the maximum

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[13] According to recent IMF estimates (Vernon and others, 2021), implicit subsidies – i.e., prices below externalities costs - in Chile were about 8.2 bn USD in 2021, which is much higher than current collected revenues from the green taxes.

[14] Law N°21.210 of 2020

[15] Combustion is defined in the Law as a process of oxidation of solid, liquid, or gaseous substances or materials that produce heat and in which energy is released to generate electricity, steam, or heat, except for raw materials used in the production processes.

[16] The Center for Climate Change, Energy and Environment of Universidad Católica estimate total emissions in Chile are around 112 CO_2eq million tons. The actual coverage of the tax is around 43 CO_2eq million tons (38 percent). The estimations with US$ 5/ton and the expansion of the base will add around $56 million or around 7 CO_2eq millions of tons more, which is around 45 percent.

amount of annual greenhouse gases, in CO_2eq, that an emitting source or establishment may emit. These caps should be based on a reference emission standard by technology, sector and/or activity in line with the national long-term climate strategy and the country NDC. Moreover, the Law states that agents may comply, partially or wholly, with emission standards through carbon credits from carbon reduction or absorption projects developed in Chile (or in the municipality in the case of local pollutants). The Ministry of the Environment must also create, manage, and maintain a public registry containing approved reduction or absorption projects, as well as certificates of carbon credits which may be traded between agents. All transfers, purchases and values of these certificates must be recorded in this registry. While these regulations should be prepared within one year of the publication of the Law, at the time of the mission the Ministry of Environment was still working on them.

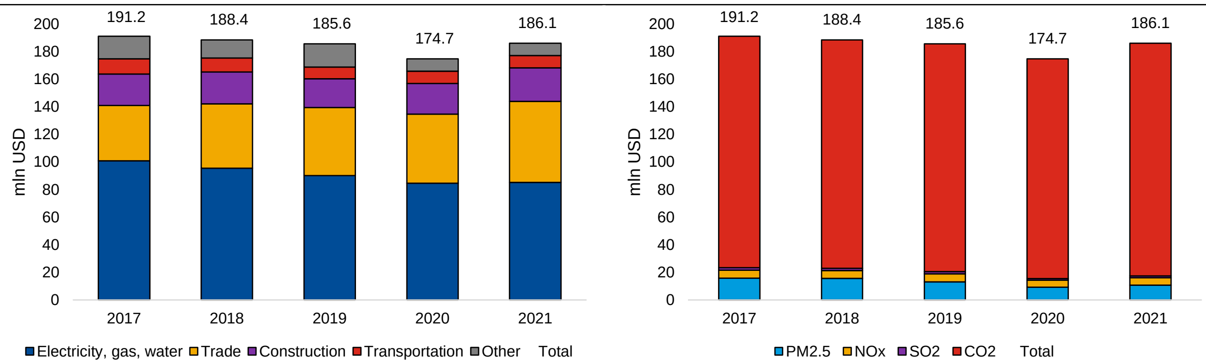
29. The Framework Law for Climate Change set the basis for GHG, as well as water use voluntary certification systems to avoid water waste. In the case of GHG, the Ministry of the Environment is responsible for granting certificates regarding the measurement, management and reporting of GHG and local pollutants. The Ministry is also responsible for issuing reduction and absorption certificates, which are voluntarily requested and meet the criteria, methodologies and requirements established by regulation. Violations will be sanctioned in accordance with the provisions of organic law of the SMA, including revoking certificates.

B. Revenue Performance

30. Revenue from the green tax on stationary sources have slightly decreased over time and its composition has also changed. Total annual revenue collected has not exceeded $200 million or about 0.06 percent of GDP and has declined by 1 percent per year since 2017. In 2020, tax revenue recorded a sharp drop due to COVID19 pandemic, when the annual decline rate was at 6 percent. In 2021, revenues recovered by 6.5 percent but remained below 2017 levels.

31. Most of the revenues come from the power sector and CO_2 emissions. Electricity, gas, and water sector accounts for almost half of the collected revenues, while trade, construction and transportation make 26, 12, 5 percent of total collected revenues, respectively. Other sectors include forestry, communications, manufacturing, mining, financial and administrative services, and personal services. About 89 percent of revenues come from CO_2 emissions (global pollutant), 7 percent – from $PM_{2.5}$ emissions, and the shares of NO_x and SO_2 emissions together are less than 5 percent.

Figure 9. Revenues Raised by the Direct Carbon Tax in 2017-2020



Source: Servicio de Impuestos Internos

C. Selected Issues

Green tax on carbon emissions

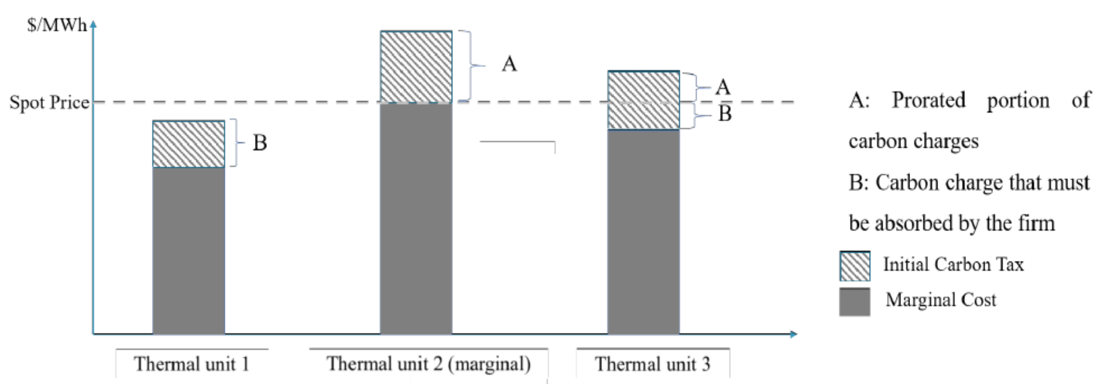
32. The direct carbon tax in Chile has design flaws that undermine its effectiveness and introduce economic inefficiencies to the power sector. The law establishes that the value of the carbon tax should not be considered in the determination of the marginal spot price of electricity (i.e., the wholesale market price) when the tax is levied on system's marginal power plant. In other words, in periods in which a fossil fuel-based power generator is the marginal unit, the carbon tax levied on such plant is excluded from the calculation of the marginal spot price for the economic dispatch. This restriction introduces distortion to the economic dispatch, as the system does not differentiate between plants with higher emissions and higher costs due to the carbon tax, and more competitive power plants with lower or zero emissions.

33. The 2014 Law also included a provision creating a cross subsidy that, contrary to the carbon tax spirit, benefits fossil fuel-based power generation. The Law states that for generation plants with a total unit cost (i.e., the variable cost considered for the economic dispatch plus the carbon tax) greater than or equal to the marginal spot price (i.e., the wholesale electricity price), the difference between the two must be covered by all utility companies in proportion to the amount of electricity each company retires (i.e., buys) from system. This provision switches the tax burden from the source of emission to utility companies buying electricity from the system[17]. Moreover, this provision is highly distortive as emitting and otherwise less competitive power plants are relieved from paying the carbon tax, which in turn offsets the economic incentive to invest in cleaner sources of power intended with the tax.

[17] This example only applies to plants that participate in the economic dispatch and the spot market. Electricity traded in Power Purchase Agreements (PPAs) may be subject to other contractual arrangements.

34. An example of a hypothetical economic dispatch illustrates the cross subsidy from utility companies to fossil fuel-based power plants.[18] Figure 9 shows three thermal plants that are dispatched in the same period. The solid bars represent the variable cost of each plant and the bars with striped lines represent the carbon tax that should be paid by each plant. For the first plant, the sum of its variable cost plus the carbon tax is below the spot or wholesale electricity market price. This means that the plant is able to bear the full cost of the carbon tax by itself. However, the spot price of electricity does not cover the carbon tax originally levied on the second and third plant. In this example, the second plant is the marginal generator and therefore sets the electricity wholesale market price equal to its variable cost (excluding the carbon tax). As a result, the carbon tax levied on this plant is prorated among all utilities companies in proportion to the electricity each retires from the system. The third plant is an inframarginal generator, as its variable cost is below the spot price (excluding the carbon tax). In this case, the portion of the tax no covered by the spot price is also prorated among utility companies.

Figure 10. Cross Subsidies from Utilities to Power Plants



Source: Gabriel Díaz, Francisco Muñoz, Rodrigo Moreno. Equilibrium analysis of a tax on carbon emissions with pass-through restrictions and side-payment rules. The Energy Journal.

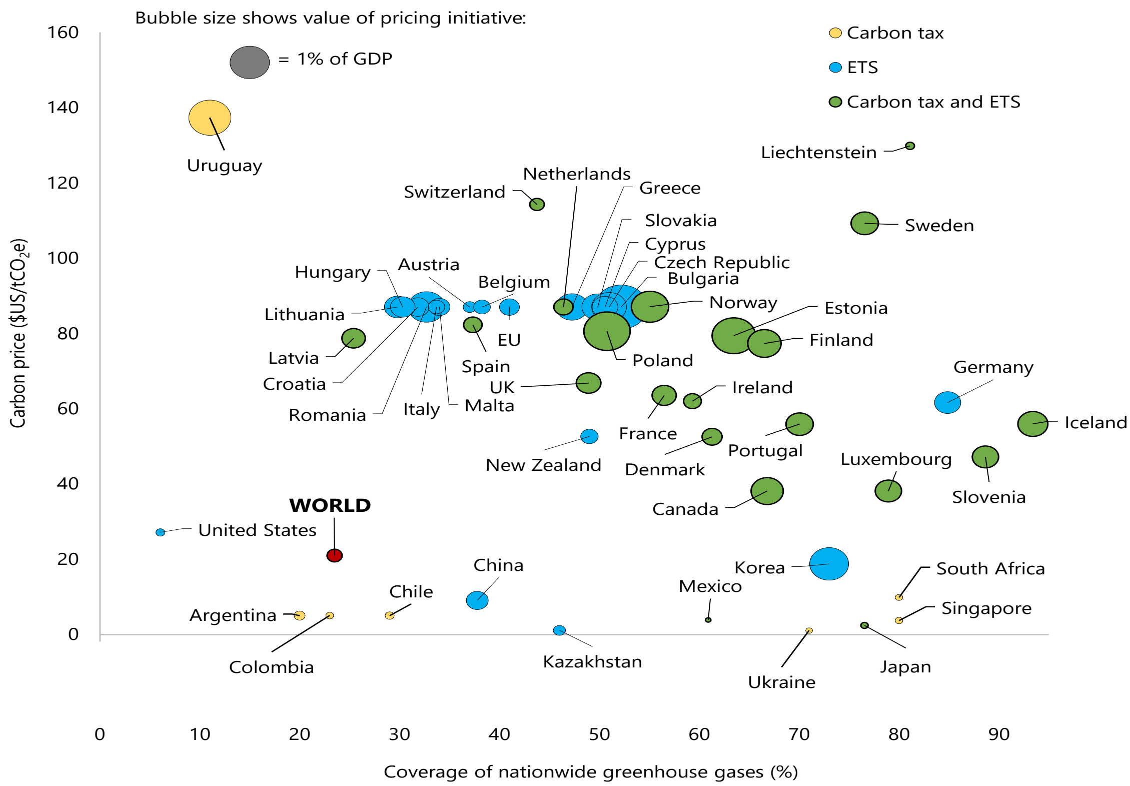
35. At $5 per ton of CO_2eq, the existing carbon tax level is low and needs to be increased, along with other measures, to achieve the country climate and fiscal goals. While the carbon tax rate in Chile is similar to that in some countries in Latin America (e.g., Argentina and Colombia), it is well below other countries in the southern cone and the OECD (see Figure 11), and the $37.5 per ton of CO_2 social cost of carbon calculated by the government.[19] For example, Uruguay introduced a carbon tax in January 2022 at a level close to $137 per ton of

[18] This is example is taken from Gabriel Díaz, Francisco Muñoz, Rodrigo Moreno. *Equilibrium analysis of a tax on carbon emissions with pass-through restrictions and side-payment rules.* The Energy Journal.

[19] See Estimación del Precio Social del CO2 2017, Gobierno de Chile, available at: http://sni.gob.cl/storage/docs/Precio%20Social%20del%20CO2.pdf

CO_2eq,[20] which the government may increase in addition to the automatic increases linked to the Consumer Price Index. Similarly, Canada increased its federal carbon tax in April 2022 to CAD$50 per ton of CO_2eq and will continue to rise it by CAD$15 per year until it reaches $170 by 2030. In addition, other measures could include higher incorporation of variable renewable energy for the power sector, low and zero emission vehicles, feebates and improved energy efficiency policies.

Figure 11. Carbon Prices around the World



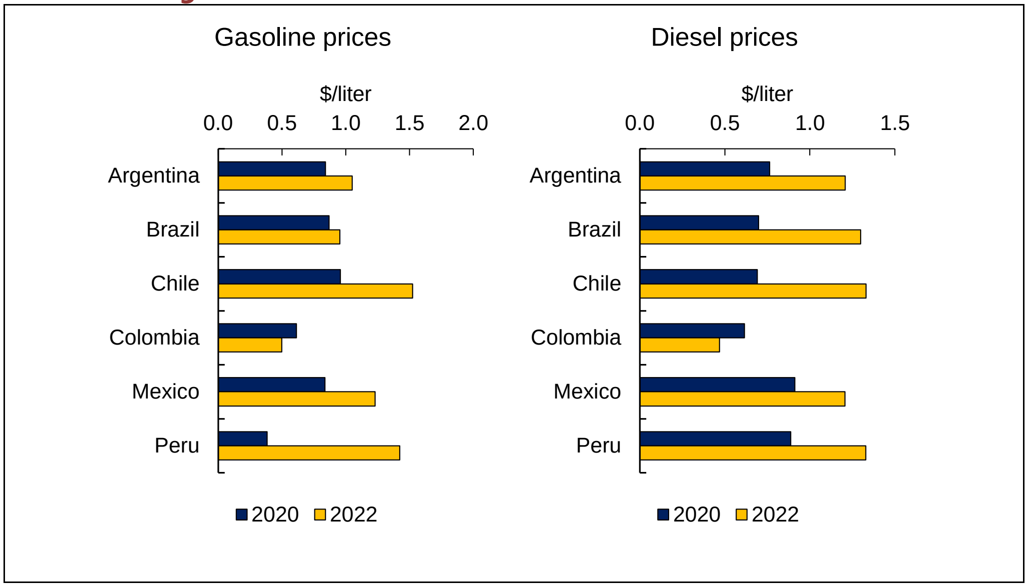
Sources: WBG (2021); IMF staff calculations; National sources.
Notes: EU ETS includes Norway, Iceland and, Liechtenstein. Prices are a weighted average between schemes. Country specific EU ETS values are calculated using sold auctions in 2020, and an average price for the period. ETS= Emissions Trading System. China's value estimate and price is based on the opening pricing of $7.40/t$CO_2$e. Canada's price reflects the federal backstop. Norway has a reduced rate on LPG natural gas of $9/t$CO_2$e**.** Denmark, Ireland and Iceland have a reduced rate for F-gases of $23/t$CO_2$e, $20/t$CO_2$e and $19/t$CO_2$e, respectively. Luxembourg prices gas at $44/t$CO_2$e. Ireland and Finland price other fossil fuel (beyond transport fuels) at $38/t$CO_2$e and $60/t$CO_2$e. Mexico's subnational schemes are not included due to lack of data.

36. Strengthening the carbon tax should be a gradual process, however, especially considering the recent global increase in energy prices. Fossil fuel increased sharply during 2021 and the first half of 2022, resulting in higher prices of electricity and refined products for households and firms in most jurisdictions (see Figure 12). Although prices have retreated somewhat recently, energy prices continue to be above pre-pandemic levels. In the case of Chile, the expected fall in fossil fuel prices may give the government an opportunity to lock-in a higher

[20] The coverage of the carbon tax in Uruguay is rather low at about 10 percent of CO_2 emissions, as it only applies to all liquid fuels, apart from jet fuel and sales of fuel to manufacturers of gasoline are also exempted.

carbon tax without increasing energy prices relative to recently observed levels. In any case, well targeted assistance[21] to low-income households may be needed. The next chapter evaluates different scenarios for Chile to improve the carbon tax and be on track to meet the country's NDC and net-zero pledge.

Figure 12. Gasoline and Diesel Price Increases in LAC-6



Sources: IMF staff, Global Petrol Prices

Green tax on local pollutants

37. Chile is a pioneer in levying taxes on local air pollutants, such as NOx, MP, and SO_2, which affect communities in areas where emitter industries are located. The rate for this type of Pigouvian tax is calculated based on a formula that includes the social cost of pollutants, the population in the municipality where the emitter is located, and an air quality coefficient that depends on the level of local population on each municipality. Specifically, the tax rate of pollutant "i" in municipality "j" is given by:

$$\mathbf{T_{ij}} = 0{,}1 \ \mathbf{x\ CCA_j\ x\ CSCpc_i\ x\ Pob_j}\ \text{, where}$$

CCA_j is an air quality coefficient equal to 1.2 if the municipality is defined as "saturated", meaning that the measurement of concentration of pollutants in the air, water or soil exceeds the value of the respective environmental quality standard; 1.1 if the municipality is defined as "latent", meaning that the concentration of pollutants is between 80 and 100 percent of the environmental quality standard; and 1.0 otherwise[22]. $CSCCpc_j$ is the per capita social cost of the

[21] Assistance is needed to limit the fiscal cost and should not undermine energy conservation incentives

[22] These classifications are defined in Law 19.300 on General Bases of Environment.

contaminant "i" set at \$0.9 for MP, \$0.01 for SO_2 and \$0.025 for NOx, and Pob_j is the population in municipality "j".

38. A simple example illustrates the impact of the air quality coefficient and the population variable on tax levels for the same pollutant in different areas. A hypothetical coal-fired power located plant in Puente Alto, a municipality of 625,500 inhabitants and defined as saturated with $PM_{2.5}$, will face an estimated tax rate of \$67,560 per ton of $PM_{2.5}$. In contrast, if the same plant is located in Contulmo, an area of 5,500 inhabitants which is neither saturated nor latent, it would face a tax rate of \$495 per ton of $PM_{2.5}$. Moreover, if the plant is expected to emit 100 tons of $PM_{2.5}$, which is the threshold at which the green tax on stationary sources is triggered, the power plant would face an annual tax of \$6.7 million in Puente Alto while only \$49,500 in Contulmo.

Green tax on mobile sources

39. The tax on emissions arising from mobile sources is limited in scope and includes multiple exemptions. While the tax is levied on the sale of new light-duty vehicles, it exempts vehicles with nine seats or more used to transport passengers, vehicles used as taxis, police and armored trucks, ambulances, tractors, and pickup trucks with a load capacity of 2,000 kilos or more. Moreover, the tax does not apply to taxpayers subject to VAT with respect to the acquisition of new pickup trucks (load capacity of up to 2,000 kilos), provided it becomes part of the taxpayer's fixed assets. While the tax on mobile sources was originally intended to improve the taxation of emissions from diesel combustion, the broad exemptions weakened its performance.

40. Chile also levies excises on fossil fuels for road transportation, although these have multiple distortions and have been found to be inefficient.[23] Excises on fuels in Chile have a dual structure, with a fixed and a variable component. The fixed (or base) component is a specific charge per quantity of fuel, while the variable component is an adjustment to the base tax, which may be positive or negative, depending on whether the international price fluctuation of the fuel (in pesos) is above or below a specified range. In practice the variable component operates as price stabilization mechanism[24] and set-up weekly by the Ministry of Finance and implemented by the Empresa Nacional del Petroleo (ENAP), a state-owned oil refining company. Moreover, different excise rates apply based on the type of fuel (much lower for diesel than for gasoline), while a system of credits operates for diesel depending on the end use of the fuel. As a result,

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[23] See "International Fuels Tax Assessment: An Application to Chile", IMF Working Paper 11/168

[24] The variable tax is known in Chile as Mecanismo de Estabilización de Precios de los combustibles (MEPCO)

Chile consumes almost double the amount of diesel than the regional average on a per capita basis[25].

41. While the analysis of fuel excises is beyond the scope of this report,[26] broader carbon pricing in the transport sector could correct distortions and achieve climate goals. This could be corrected in various ways. First, the excise rate on diesel could gradually increase to be on par with that of gasoline. Alternatively, the same carbon tax applied to stationary sources, although at a higher level as proposed in the next chapter, could also apply to the transport sector. Other options include an ETS, a hybrid combining a higher carbon tax and an ETS, or a pure feebate mechanism (see Box 1). The carbon tax could be incorporated using the existing excise or VAT structure for fossil fuel, while the feebate mechanism could leverage institutional capacity developed for the green tax on mobile sources.

Offsets and carbon credits

42. The proposed offset mechanism introduced in the Tax Modernization Law and the Framework Law on Climate Change should be carefully implemented. While offsets would allow emitters to purchase and retire credits generated by other entities to compensate for own emissions and reduce their carbon tax burden, these schemes remain controversial and various countries have banned their use[27]. In theory, entities purchasing credits compensate for their emissions and the respective carbon tax by paying for reductions elsewhere. Offsets mechanisms are usually difficult to verify and monitor and can distract policy efforts from instruments that effectively reduce emissions (e.g., carbon pricing). Moreover, offsets may increase net emissions if underlying credits are not additional[28] and can lead to green washing.

43. The Law restricts offsets and carbon credits to projects developed in Chile (and the municipality in the case of local pollutants), which mitigates some of the risks evidenced by this mechanism in international transactions. One of the main risks is that offsets would lead to abatement in low-cost jurisdictions, when trade is allowed at the international level. This will not be the case in Chile if the domestic and local restrictions are maintained. However, carbon offsets will lower fiscal revenue, even if limited to domestic projects.

D. Recommendations

- Include the carbon tax in the variable cost of all generation plants considered for the economic dispatch.

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[25] See "Tax Expenditures and Corrective Taxes in Chile", International Monetary Fund, Washington, DC, (November 2021)

[26] Idem

[27] For example, EU banned the use of international offsets in 2021.

[28] Additionality means that a reduction in GHG emissions would not have happened without the offset.

- Eliminate the cross subsidy from utilities to fossil fuel-based power plants.
- Increase the carbon tax and set a path to gradually increase it over time to reach a level consistent with the country's NDC and pledge to net zero.
- Complement the tax on mobile sources with higher excises on diesel or by including the transport sector in a broader carbon pricing scheme.
- Consider increasing the social cost of contaminants for $PM_{2.5}$, NO_x and SO_2.
- Continue to geographically restrict carbon offsets and credits to emission reduction or absorption projects developed in Chile (and in municipalities for local pollutants).

IV. OPTIONS TO ENHANCE CARBON PRICING

A. Principles and Conceptual Issues

44. Ideally carbon pricing would be the centerpiece of a country's mitigation strategy. Carbon pricing has several key attractions as it:

- Promotes the full range of opportunities for reducing energy use and shifting to cleaner energy sources across all covered sectors by reflecting the cost of carbon emissions in the prices of fuels, electricity, and other goods;
- Automatically minimizes the costs of these responses by equalizing the cost of the last ton of CO_2eq reduced across fuels and sectors;
- Levels the playfield for clean technology investments by establishing a clear price signal;
- Mobilizes a valuable source of revenue which can be used to help meet climate, social, or broader fiscal objectives;
- Generates domestic environmental co-benefits such as reductions in local air pollution deaths; and
- Is straightforward to scale-up from an administrative perspective, in Chile's case building off already established capacity for green taxes.

45. Carbon pricing can take the form of carbon taxes or an ETS. Carbon taxes are usually implemented through a tax on the carbon content of fossil fuel supply, as is the case with the existing tax carbon and local pollutants for stationary sources. ETS require firms to acquire allowances for their emissions or the carbon content of their fuel supply, with the government controlling the supply of allowances and market trading of allowances establishing the emissions price.

46. To achieve Chile's 2030 NDC and legally binding mid-century net-zero pledge, carbon pricing needs to: (i) cover a wide range of emissions; (ii) establish a rising and predictable price; and (iii) avoid unnecessary inefficiencies due to exemptions. These principles could be met through the enhancement of the existing carbon tax, developing the ETS provided for in the Climate Change Framework Law, or a hybrid approach with taxes and ETS covering different emissions sources. The choice between these three approaches, which are briefly discussed below, will depend on several factors, including existing and required additional institutional capacity, recent experience with green taxes, and which ministry should be primarily responsible for mitigation policy (carbon taxes are naturally under the purview of the finance ministry and the ETS under the environment ministry).

47. The most economically and environmentally effective form of a carbon tax would price all CO_2 emissions at the same level, with the price ramping up predictably each year. This would require removing any existing exemptions so all fossil fuels in all sectors are taxed in proportion to their full carbon content. Ideally, the carbon tax rate would ramp up as rapidly as possible, subject to acceptability constraints. For example, if the maximum acceptable tax rate in 2030 is set at US$60 per ton (see quantitatively analysis below), the tax could have a step increase to US$15 per ton in 2023 and ramp up by US$6.4 per year thereafter. Acceptable tax rates will also depend on progress on carbon pricing in other major trading partners, so some future discretion may be needed to adjust planned tax increases.

48. The authorities could also choose to rely on a ETS as the principal tool for carbon pricing in Chile, although this will require to establish additional institutional capacity. The ETS could cover the sectors (e.g., power and industry) where emissions are generally more responsive to pricing. Extending the coverage of the ETS to emissions to transportation and buildings would require applying it midstream to the suppliers of fuels for those sectors based on the carbon content of those fuels. In principle, a trajectory of progressively tighter emissions caps could be specified in line with the 2030 NDC, though this might lead to prices that exceed acceptable levels. Price increases might be contained through combining the ETS with a ceiling price where extra allowances are put into the system at this price to prevent further price increases. Prices may also be volatile as they vary with shifts in the demand and supply of fuels and this price uncertainty can deter clean technology investments with high upfront costs and long-range emissions reductions. Price stability can be promoted through combining the ETS with an exogenous price floor—implemented, for example, through a minimum price on allowance auctions—where the floor price ramps up predictably over time.

49. While an ETS could exploit the fiscal opportunities from carbon pricing, this could in turn imply higher overall costs for the economy. If allowances were fully auctioned (with revenues transferred to the finance ministry), ETS would raise the same revenue as an equivalently scaled carbon tax—these revenues could be used to boost growth and employment, for example, by modifying the tax mix and funding socially productive investments (e.g., Sustainable Development Goals). In contrast, freely allocating allowances to firms in a lump sum fashion provides windfall profits to them without improving economic efficiency and forgone fiscal revenues to the government become larger as ETS prices rise over time. A key motivation for free allowance allocations is that they help to address concerns about industrial competitiveness, but border carbon adjustment is a potentially more effective instrument for this.

50. Under a hybrid approach, the ETS could address emissions from the industry and building sectors and the carbon tax emissions from the power and transportation sector. These hybrid approaches have been used elsewhere—for example, in the EU power and industry emissions are covered by the EU-wide ETS while several member states (e.g., Denmark, Finland, France, Ireland, Portugal, Sweden) have applied national carbon taxes to the transportation and building sectors. Cost effectiveness would require aligning carbon prices across the tax and ETS, for example by setting a trajectory of price floors under the ETS equal to the trajectory of carbon tax rates. Another cost-effective alternative would be to apply feebates (tax-subsidy schemes) in certain sectors where acceptability of higher carbon taxes is highly uncertain (see Box 1).

Box 1. Feebates as an Alternative to Carbon Pricing[29]

Feebates apply a revenue-neutral, sliding scale of fees on products or activities with above average emission rates and a sliding scale of rebates on products or activities with below average emission rates. Feebates can be combined with and complement carbon pricing schemes to reduce emissions per unit of production or activity in the transport, industrial, building, forestry and agricultural sectors.

Feebates: (i) provide a more flexible and cost-effective approach than regulations; (ii) can provide strong mitigation incentives; (iii) avoid large tax burdens on the average household or firm; (iv) avoid fiscal burdens for the government; and (v) can often build off existing administrative capacity. While they would need to be adapted to the specific circumstances in Chile (perhaps with changes to green taxes on mobile sources and fossil fuels), feebates are attractive for:

- Transportation, where (relative to the current tax system) they provide more fine-tuned incentives for lower emission vehicles;
- Industry, where they provide incentives for cleaner production processes with less concern about competitive impacts and emissions leakage (compared with carbon pricing);
- Buildings where they can reinforce incentives for transitioning to electric heating and more energy efficient appliances;
- Land use, where they provide more comprehensive incentives for carbon storage (in forests and peat land) and can be designed to be fiscally neutral (in contrast to afforestation subsidies); and
- Agriculture, where they promote shifting to less emissions-intensive practices (indirectly taxing emissions is an alternative though, to avoid leakage).

Feebates are applied by finance ministries, whereas regulations are the more natural instrument when climate policy is delegated to environmental ministries. Feebates can be more flexible and cost effective than regulations—the latter are only cost-effective with extensive credit trading provisions across firms and time. And feebates can be implemented quickly with minimal administrative cost, at least in cases (e.g., transportation, industry, residential heating) where they would build off existing administration for taxes and subsidies.

[29] For a more detailed discussion see Parry, I. (2021). The critical role of feebates in climate mitigation strategies

B. Quantitative Evaluation of Carbon Pricing Options

51. This section models three carbon tax enhancement options and one hybrid approach to meet Chile's climate goals.

- **Moderate**: set the carbon tax at $15 per ton of CO_2 in 2025, increasing linearly to $50 per ton of CO_2 in 2035. The tax covers power, buildings, industry, rail, and aviation sectors but exempts the road transportation sector.
- **Base case**: set the carbon tax at $15 per ton of CO_2 in 2024, increasing linearly to $60 per ton of CO_2 in 2030. The carbon tax excludes gasoline and diesel, but the excise on diesel is increased to bring the effective carbon rate equal to that of gasoline (starts from $0.05/liter in 2024 and increases linearly to $0.37/liter in 2030)[30]. The carbon tax applies to all energy sectors.
- **Hybrid**: consists of two parts.
  - Carbon tax applies only to the power sector, starting from $5 per ton of CO_2 (current level) in 2024 and increases at a lower slope at the beginning, up to $11 per ton of CO_2 in 2027. It then increases with a steeper slope up to $60 per ton of CO_2 in 2035.
  - Emissions Trading System (ETS) in the industrial sector, starting from $5 per ton of CO_2 (current level) in 2024, increasing at a lower slope at the beginning, up to $11 per ton of CO_2 in 2027. It then increases with a higher slope up to $60 per ton of CO_2 in 2035.
- **Social cost of carbon (SCC)**: economy-wide carbon tax starting from $35 per ton of CO_2 in 2024 and increasing linearly to $75 per ton of CO_2 in 2030.

52. The report analyzes each of the carbon pricing[31] scenarios in terms of their impact on emissions, revenues and GDP, their distributional impacts, as well as in terms of comparing efficiency costs with domestic environmental co-benefits.

53. The analysis was conducted using Climate Policy Assessment Tool (CPAT), a spreadsheet model developed jointly by the IMF and the World Bank, which is routinely used for cross-country and individual country assessments of mitigation policies. CPAT provides estimates for over 200 countries of future fuel use and emissions by major energy sector as well as the emissions impacts of a diverse range of pricing and non-pricing mitigation approaches. Covering over 200 countries, CPAT provides projections of fuel use and CO2 emissions for the four major energy sectors—power, industry, transport, and buildings.

[30] Alternatively, the tax rate for diesel could be aligned with that of gasoline in terms of tax monthly units (as determined by SII), although in terms of carbon content equivalency diesel would continue to be undertaxed.

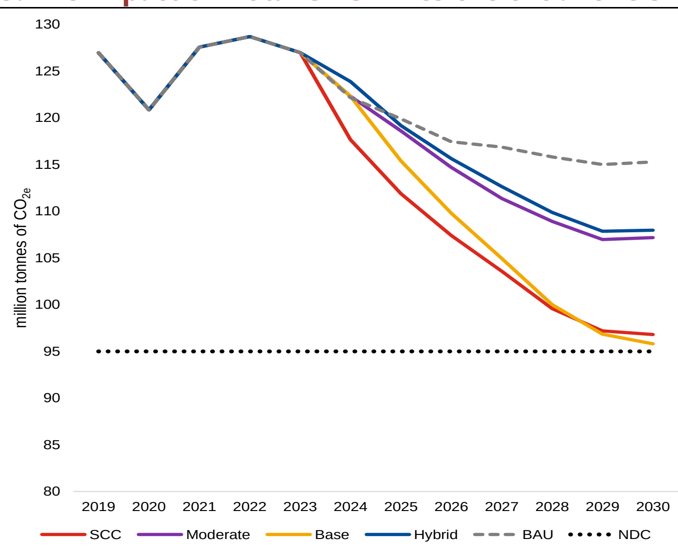
[31] From now on, carbon pricing refers both to carbon tax and ETS.

CPAT is calibrated to be consistent with modeling literature on the key parameters. Fuel and electricity price responsiveness is parameterized to be broadly consistent with empirical evidence and results from energy models (fuel and electricity price elasticities over the longer term are generally between -0.5 and -0.8). Carbon emissions factors by fuel product are from IIASA (2021), and emissions in 2019 are calibrated to match those of implied by UNFCCC GHG and emissions in 2020-1 calibrated to match those of EC-JRC (Crippa and others 2018), Global Carbon Budget (Friedlingstein and others 2021), and various sources.

Emissions analysis

54. The base and SCC scenarios bring GHG emissions in line with the NDC target by 2030. The moderate and hybrid scenarios, however, are halfway between the BAU emissions and the NDC target due to not full coverage (moderate excludes transport and hybrid applies only to industry and power). Total emissions are reduced by 17, 7, 16, and 6 percent relative to BAU in base, moderate, SCC and hybrid scenarios, respectively. Cumulatively over 2024-2030 period, carbon pricing would reduce CO_2 emissions by 51, 20, 59, and 17 million tons in the base, moderate, SCC and hybrid scenarios, respectively. Under all scenarios, the country would benefit from implementing other non-carbon pricing measures to reach its NDC.

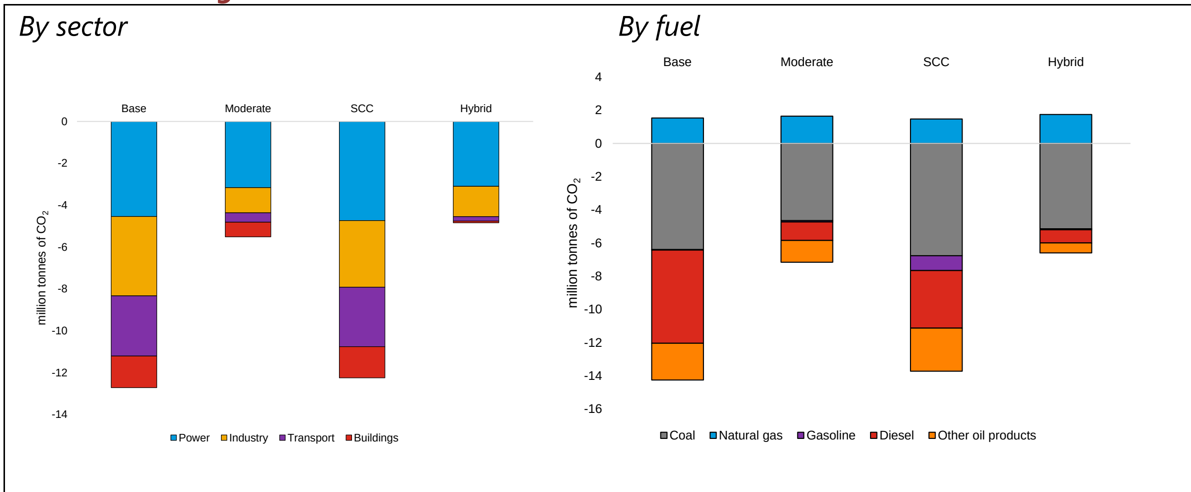
Figure 13. The Impact on Total GHG Emissions excl. LULUCF by Scenario



Source: IMF staff using CPAT

55. In all scenarios, most of the reductions in CO2 emissions on a sectoral level come from the power sector and industry. Power sector accounts for 36-64 percent of CO_2 emissions reductions in 2030 across all scenarios.[32] The second highest reduction comes from the industry sector (22-30 percent in 2030). Transport accounts for 8-23 percent of emissions reductions in 2030, followed by buildings sector with between 2 and 13 percent of the reduction.

Figure 14. CO_2 Emissions Reductions from the Baseline in 2030



Source: IMF staff using CPAT

56. Coal emissions will decrease significantly while natural gas emissions would moderately grow. Even despite the coal phase-out in the power sector in the BAU, from a half to four-fifths of emissions reductions in 2030 come from coal in power and other sectors. Diesel emissions account for 20-44 percent of total emissions reductions in 2030, while gasoline emissions are excluded in one scenario (base) and less responsive in other scenarios, making up less than ten percent of total emissions reduction. Natural gas emissions, on the other hand, are expected to grow mainly driven by the shift from coal to natural gas in the power sector.[33]

Fiscal and macro implications

57. Carbon pricing might be a significant source of additional revenues,[34] raising up to 1.6 percent of GDP in 2030 on top of BAU. Cumulatively over 2024-2030, the revenues collected in addition to the baseline revenues vary from $7 billion in the moderate scenario to $29 billion in the SCC scenario. In 2030 alone, the moderate scenario would bring additional 0.8

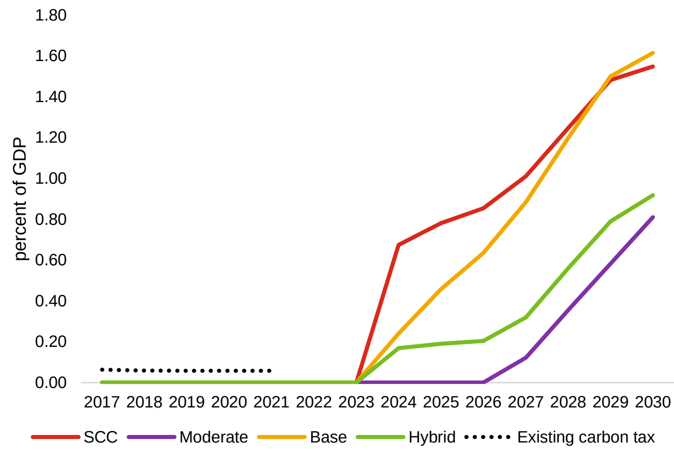
[32] Under an assumption of no existing bottle necks in the power system. Existence of bottle necks would delay the effect of behavioral responses on carbon taxation and must be addressed for the tax to reach its full potential.

[33] Baseline energy prices were relatively high at the time of the analysis, which could have a positive impact on the results of the carbon pricing scenarios chosen.

[34] Revenue calculations include the effect of tax base erosion from the carbon tax. The calculations exclude the impact of a system of offsets starting in February 2023, which may bias the calculations upwards.

percent of GDP in revenues, compared with 1.6 percent from the SCC scenario. The existing carbon tax raised no more than 0.06 percent of GDP in 2017-2021.

Figure 15. Additional Revenues Raised from Fossil Fuels by Scenario, Percent of GDP

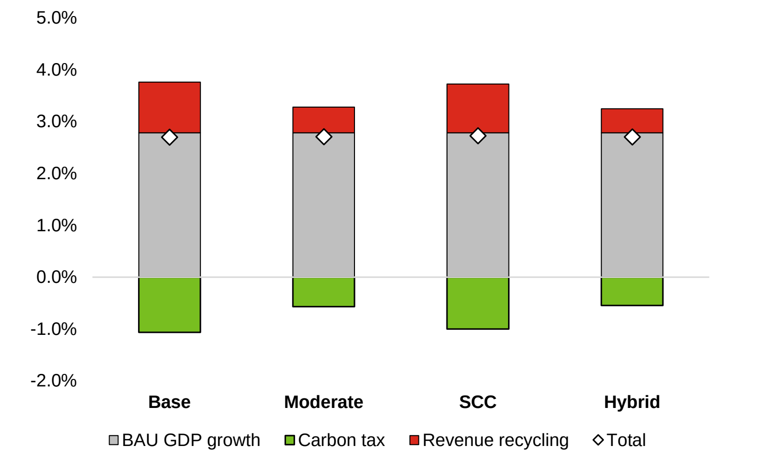


Source: IMF staff using CPAT

58. Higher carbon pricing would have a negative on GDP growth, but this could be partially or totally offset with effective revenue recycling.[35] The potential negative impact on GDP growth in 2030 is 1.1, 0.6, 1.0, 1.5 percentage points in the base, moderate, SCC, and hybrid scenarios, respectively. However, in an illustrative scenario, where 70 percent of revenues collected from the carbon tax are recycled effectively through productive public investment, and 30 percent are recycled through targeted cash transfers, the negative impact would almost be completed offset, reducing it to just 0.1 percentage points. The extent of the reversal of the negative impact on GDP growth will depend on the value of the Keynesian fiscal multiplier of the policies chosen to recycle revenues from carbon pricing.

[35] See next chapter for a conceptual discussion on different revenue recycling options.

Figure 16. Impact on GDP Growth in 2030



Source: IMF staff using CPAT

Prices analysis

59. Carbon pricing is likely to put upward pressure on energy prices, with the highest impact on coal, followed by electricity and road fuels. Weighted average coal prices would increase by 98, 47, 126, and 97 percent compared to BAU in the base, moderate, SCC, and hybrid scenarios, respectively. Coal, however, is an intermediate input used by firms rather than directly consumed by households. Electricity prices would increase about by 3-4 cents per kilowatt hour[36] (or 25 percent compared to BAU or baseline in 2030) in each scenario. However, electricity prices are projected to decrease in Chile, as more variable renewable capacity comes online between now and 2030. For example, electricity prices today are about $0.17 per Kilowatt hour (kWh) for residential use, decreasing to $0.15 kWh in the baseline case. Similarly, electricity prices for industry are $0.15 kWh, decreasing to $0.10 kWh in the baseline case. Therefore, the impact of the carbon prices would only represent a modest increase from current prices. Falling electricity prices are good opportunity for the government to lock-in higher carbon prices. Gasoline prices would grow by 7-15 percent relative to BAU (excluding the base scenario), while diesel price increases would be slightly higher – 10-45 percent relative to BAU.

[36] This increase will bring electricity prices in Chile on par with electricity prices in other LAC6 countries without high carbon tax: weighted average baseline electricity prices in Argentina in 2030 are $0.12/kWh, in Brazil and Peru - $0.16/kWh, in Colombia - $0.15/kWh, and $0.13/kWh in Mexico.

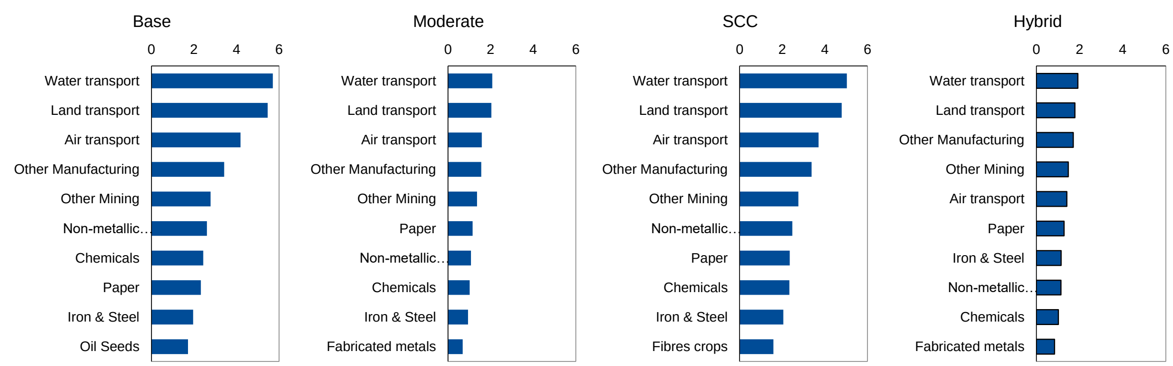
Table 2. Energy Prices by Scenario in 2030

Fuel	Unit	Current	Baseline	Base	Moderate	SCC	Hybrid
Electricity, residential	$/kWh	0.19	0.15	0.19	0.18	0.19	0.18
Electricity, industry	$/kWh	0.16	0.10	0.13	0.13	0.13	0.13
Coal	$/GJ	4.1	5.1	10.1	7.5	11.6	10.1
Natural gas	$/GJ	27.3	25.5	28.7	27.1	29.5	27.6
Oil	$/bbl	65.7	50.6	78.7	65.8	85.8	65.3
Gasoline	$/lit	1.2	1.3	1.3	1.4	1.5	1.4
Diesel	$/lit	0.8	1.0	1.4	1.1	1.2	1.1
LPG	$/lit	0.8	0.5	0.6	0.6	0.7	0.6
Kerosene	$/lit	0.9	0.7	0.9	0.8	1.0	0.8

Source: IMF staff using CPAT

60. Carbon pricing would also lead to slight increases in the cost of industrial production, which may raise competitiveness concerns,[37] especially for energy-intensive, trade-exposed (EITE) industries. Production cost increases have three components. First, industrial firms will incur a direct tax payment, or allowance purchase requirement, for emissions they continue to emit directly. Second, firms will incur abatement costs to the extent they cut emissions, for example, by switching to cleaner (but costlier) technologies and fuels. Third, they incur an indirect payment for carbon charges on emissions embodied in their inputs, especially electricity. Overall, carbon pricing in 2030 would increase production costs for non-metallic industries (most notably cement), iron and steel, and chemicals by less than 6 percent in the SCC and base scenarios (relative to BAU costs in 2030).

Figure 17. Percent Change in Output Prices by Scenario in 2030 (Output Price Increase, %)



Source: IMF staff using CPAT

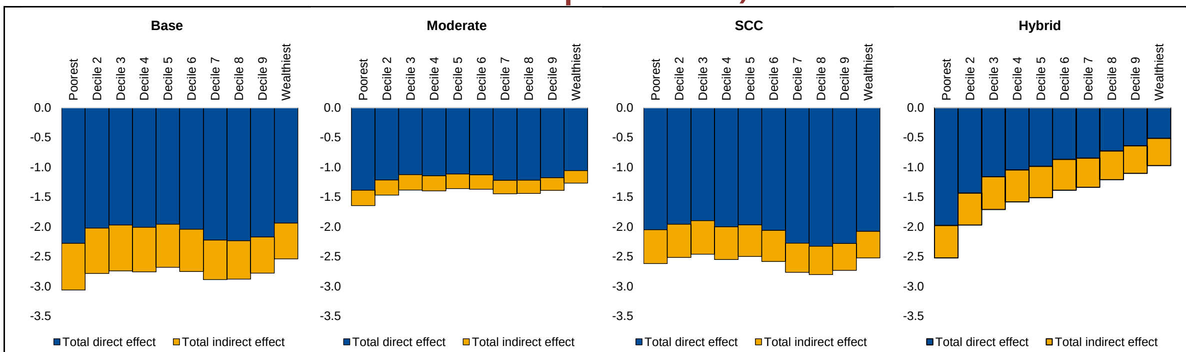
[37] While it is not a focus of this study, addressing competitiveness concerns might include policies such as border carbon adjustment (BCA) or free allowances allocation for EITE industries in case of ETS.

Distributional impact and co-benefits

61. Civil society and some interest groups may oppose carbon pricing because of the burden of higher energy prices on households. Therefore, evaluating the household incidence from carbon pricing is important and measures should be taken to counteract these burdens. The analysis is based on a two-step approach to assess the distributional impacts of the reforms. Firstly, using input-output tables to calculate the effect of carbon pricing on different categories of consumer goods; and secondly, mapping price increases to data on budget shares for different goods by household income group using household expenditure surveys.

62. The results of the distributional analysis show that the impact of the carbon pricing is revenue-neutral for carbon tax scenarios and regressive for hybrid. The modelling suggests that carbon pricing imposes a burden on an average household of 1.5-3 percent of consumption. The burdens are largely driven by direct increases in the price of fossil fuels and electricity. However, these estimates overstate the net burden of carbon pricing on households in two regards. Firstly, they ignore partially offsetting domestic environmental benefits, especially local air pollution mortality. Second, they ignore the benefits from recycling carbon pricing revenues.

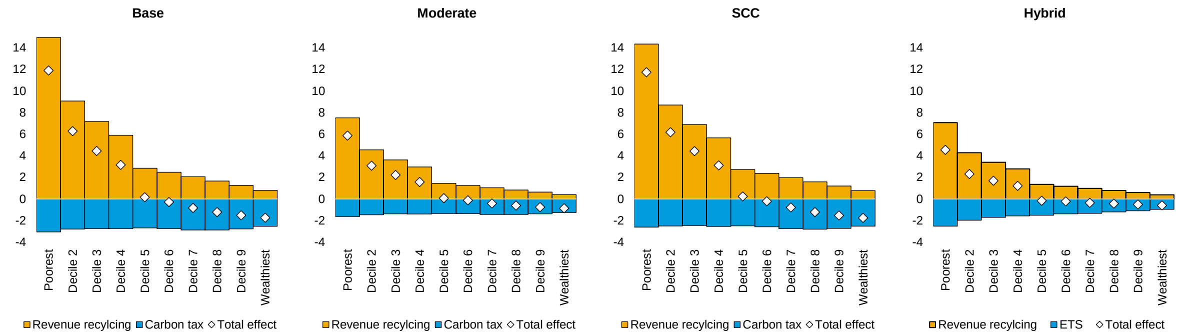
Figure 18. Relative Mean Consumption Effect before Revenue Recycling (% of Baseline Consumption in 2030)



Source: IMF staff using CPAT

63. Revenue recycling would offset the negative impact of carbon pricing on households, while targeted recycling could even make the reforms pro-poor. For example, using 30 percent of the revenues for a targeted, unconditional cash transfer aimed at the bottom four consumption deciles and using other 70 percent of the revenues to invest in public infrastructure, would make the reform both pro-poor and equity enhancing. On net, the bottom four deciles are better off from the reform with net benefits amounting to about 4-12 percent of consumption. The next three deciles are approximately no better or worse off, while wealthier households are worse off on net but by only 2 percent of consumption.

Figure 19. Relative Mean Consumption Effect after Revenue Recycling (% of Baseline Consumption in 2030)



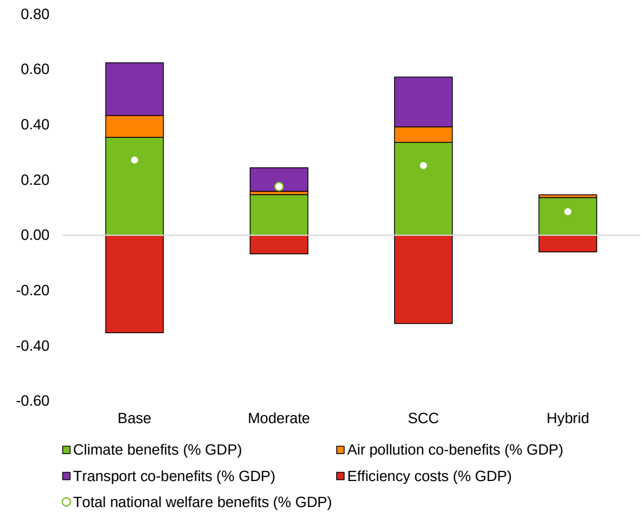
Source: IMF staff using CPAT

64. Carbon pricing imposes a relatively small economic cost in Chile equivalent to about 0.1-0.4 percent of GDP in 2030 and they are offset by domestic environmental co-benefits. Economic costs reflect pure mitigation costs[38], primarily the annualized costs of using cleaner but more expensive technologies instead of fossil-based technologies (net of any savings in lifetime energy costs). The carbon pricing does not impose a net cost on Chile, before even counting the climate benefits. 10-30 percent of the domestic environmental co-benefits reflect fewer local air pollution deaths and 70-90 percent reductions in traffic congestion and accident externalities.[39] Adding the global climate benefits increases environmental benefits from 0.2-0.4 to 0.2-0.6 percent of GDP, or two-three times the economic efficiency cost.

[38] Estimation of economic costs is made under specific assumptions on emissions projections and responsiveness of emissions to carbon pricing (reflecting marginal abatement cost curves). See Black and others (2022) on methodology for estimating the economic costs.

[39] See Parry and others (2014) on methodologies for quantifying the broad range of environmental impacts of fossil fuel use on a country-by-country basis.

Figure 20. Economic Costs and Domestic Environmental Co-benefits in 2030 (% of GDP)



Source: IMF staff using CPAT

65. The table below summarizes the main results across different scenarios, which might be helpful to weigh different trade-offs in the decision-making process.

Table 3. Summary Table

Scenario	Base	Moderate	SCC	Hybrid
Energy-related CO_2 emissions reduction in 2030, % to a BAU	17%	7%	16%	6%
Cumulative CO_2 emissions reductions in 2024-2030, MtCO2	51	20	59	17
Additional fiscal revenues raised in 2030, % of GDP	1.61	0.81	1.55	0.92
Cumulative additional fiscal revenues raised in 2024-2030, bn USD	25.3	7.4	29.1	12.3
Impact on GDP growth in 2030, percentage points deviation from the BAU growth	-0.09%	-0.08%	-0.06%	-0.08%
Residential electricity price increase in 2030, percent from the BAU price	24%	22%	25%	22%
Residential electricity price increase in 2030, percent from the current price	-4%	-6%	-3%	-5%
Industrial electricity price increase in 2030, percent from the BAU price	27%	24%	28%	24%

Industrial electricity price increase in 2030, percent from the current price	-19%	-20%	-17%	-20%
Relative mean consumption effect on the poorest after revenue recycling, % of BAU consumption	11.9	5.9	11.7	4.5
Pure abatement costs, % of GDP	0.35	0.07	0.32	0.06
Domestic co-benefits (transport, air pollution, climate), % of GDP	0.62	0.24	0.57	0.15

V. REVENUE RECYCLING OPTIONS

66. Defining how revenue from higher carbon taxes will be spent and explaining it clearly to the public will be a critical step to receive political support in Congress. The Ministry of Finance informed the mission that the main purpose of the carbon tax reform is not to generate additional revenue, but to induce changes in consumption behavior to reduce social costs and comply with the country's climate goals. While earmarking is not allowed in Chile, the Ministry is exploring different uses of carbon tax revenue, to offset the impact of a higher carbon tax partially or completely on GDP growth, energy prices and income distribution.

67. Voters and specific interest groups in Chile, as in many countries, are likely to oppose carbon tax increases because they fear impacts in energy prices and in the cost of living.[40] Given the recent increase in energy prices in the country, higher carbon taxes may also face public opposition if the reform is perceived as imposing an additional burden on low-income families. Similarly, energy-intensive and trade-exposed firms, which cannot easily pass on higher energy costs in product prices, are also likely to be vocal opponents to higher carbon taxation.

68. Overcoming this political and public debate will require building a broad and diverse coalition in favor of the reform. One way to achieve this is to clearly explain to the public how revenue from higher carbon taxes will be spent, considering both economic efficiency and implications for income distribution. Successfully socializing the carbon tax reform and how revenue will be used is likely to garner support from environmental organizations, some business groups, and the general public.

69. The government should develop a well-planned strategy to communicate how revenue from higher carbon taxes will be spent.[41] Options for revenue use should be assessed against impacts on income distribution and economic efficiency, as well as administrative burden (see **Error! Reference source not found.**). Broad categories of possible expenditure choices (see Annex for examples of how countries use carbon pricing revenues) include cash transfers, environmental or general investment, deficit reduction or lower taxes. For example, universal transfer payments (i.e., equal dividends to all households regardless of income) might help with political acceptability but would forgo potentially sizable efficiency benefits from productive revenue use. Alternatively, the government could offer relief for households through a direct transfer or through lower energy bills, although this would not offset the significant indirect burden from generally higher consumer prices. Environmental investments (low-carbon infrastructure, energy networks, R&D) may also be favored by voters as part of a package.

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[40] Carbon taxes would certainly add to the cost of living for all households, but the burden as a share of total household consumption would depend on the share of income spent on energy by different income levels.

[41] For a more detailed discussion and country examples on how to use carbon tax revenue see: "Using Carbon Revenues". Note 16. World Bank, Washington, DC. World Bank.

However, these investments would need to be balanced against competing investment priorities and scrutinized to ensure high quality, as with other important investments (e.g., healthcare, water and sanitation, etc.). While we understand the authorities are currently not considering tax cuts for labor or consumption, reducing these taxes could also promote some of these efficiency gains and would benefit households roughly in proportion to their income.

Table 4. Options for Recycling Higher Carbon Tax Revenue

Instrument	Metric		
	Impacts on income distribution	Impact on economic efficiency	Administrative burden
General Revenue Uses			
Environmental investment	May disproportionately benefit low-income households (for example, if their vulnerability to natural disasters is reduced)	May be less efficient than broader uses of revenues	Modest
General investments	May disproportionately benefit low-income households (for example, if basic education, healthcare, and infrastructure provided)	Potentially significant	Modest
Universal transfers	Highly progressive (disproportionately benefits the poor relative to higher income)	Forgoes efficiency benefits	New capacity needed (but should be manageable)
Payroll tax	Benefits are largely proportional across working households	Improves incentives for formal work effort	Minimal
Personal income tax	Typically, benefits are skewed to higher-income groups	Improves incentives for formal work effort, and saving reduces tax sheltering	Minimal
Consumption tax	Largely proportional to households' consumption	Some improvements in incentives for formal work effort	Minimal
Corporate income tax	Benefits are skewed to higher-income groups	Improves incentives for investment	Minimal
Deficit reduction	Benefits accrue to future generations	Significant (lowers future tax burdens and macro-financial risk)	Minimal
Targeted assistance			
Means-tested cash, in-kind transfers	Effective in helping low-income groups if social safety nets are comprehensive	Efficiency impacts unclear but likely modest	Low, if builds on existing capacity, otherwise significant
Assistance for household energy bills	Provides partial relief for all households (for example, does not help with indirect pricing burden)	Modest reduction in environmental effectiveness	Low, if builds on existing capacity, otherwise significant

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Appendix 1. Carbon Taxes, ETS and Revenue Use

Country/ Region	Year Introduced	Coverage of Energy Sectors: Power	Industry	Transport	Buildings	Coverage Rate, all GHGs (percent)	Price, $/tonne	Revenue/ Rent, % GDP	Point of Tax/ Regulation	Revenue Use
Carbon Taxes										
Argentina	2018	✓	✓	✓		20	5	0.070	Midstream	General budget
Colombia	2017	✓	✓	✓	✓	23	5	0.04	Midstream	Environmental spending
Chile	2017	✓	✓			29	5	0.05	Downstream	General budget
Indonesia	2022	✓				26	2	0.05	Midstream	General budget
Singapore	2019	✓	✓			80	4	0.04	Midstream	General budget
South Africa	2019	✓	✓	✓	✓	80	10	0.04	Midstream	General budget
Ukraine	2011	✓	✓		✓	71	1	0.05	Midstream	General budget
Uruguay	2022		✓	✓		11	127	1.15	Midstream	General budget, environmental spending
ETSs										
EU	2005	✓	✓			41	87	0.26	Downstream	General budget, environmental spending
Austria	2005	✓	✓			37	87	0.11	Downstream	General budget, environmental spending
Belgium	2005	✓	✓			38	87	0.19	Downstream	General budget, environmental spending
Bulgaria	2005	✓	✓			52	87	1.82	Downstream	General budget, environmental spending
Croatia	2005	✓	✓			32	87	0.33	Downstream	General budget, environmental spending
Cyprus	2005	✓	✓			51	87	0.43	Downstream	General budget, environmental spending
China	2013, 2014, 2016, 2021	✓				38	9	0.32	Downstream	Environmental spending proposal
Czech Republic	2005	✓	✓			51	87	0.78	Downstream	General budget, environmental spending
Germany	2005, 2021	✓	✓	✓	✓	85	62	0.44	Mid & Downstream	Environmental spending
Greece	2005	✓	✓			47	87	0.66	Downstream	General budget, environmental spending
Hungary	2005	✓	✓			30	87	0.39	Downstream	General budget, environmental spending
Italy	2005	✓	✓			34	87	0.18	Downstream	General budget, environmental spending
Kazakhstan	2013	✓	✓		✓	46	1	0.10	Downstream	General budget
Korea	2015	✓	✓	✓	✓	73	19	0.99	Downstream	Environmental spending
Lithuania	2005	✓	✓			30	87	0.44	Downstream	General budget, environmental spending
Malta	2005	✓	✓			34	87	0.28	Downstream	General budget, environmental spending
New Zealand	2008	✓	✓	✓		49	53	0.20	Downstream	General budget, environmental spending
Romania	2005	✓	✓			33	87	0.89	Downstream	General budget, environmental spending
Slovakia	2005	✓	✓			50	87	0.64	Downstream	General budget, environmental spending
US	2009, 2012, 2018, 2021	✓	✓	✓	✓	7	24	0.05	Up & Midstream	General budget, direct transfers, environmental spendin
Hybrid										
Canada	2019	✓	✓	✓	✓	67	38	0.16	Downstream	Tax cuts, environmental spending
Denmark	1992, 2005	✓	✓	✓	✓	62	52	0.29	Mid & Downstream	General budget
Estonia	2000, 2005	✓	✓			63	79	1.26	Mid & Downstream	General budget
Finland	1990, 2005	✓	✓	✓	✓	67	77	0.76	Mid & Downstream	General budget, tax cuts
France	2005, 2014	✓	✓	✓	✓	56	64	0.41	Mid & Downstream	General budget, environmental spending
Iceland	2005, 2010	✓	✓	✓	✓	93	56	0.62	Mid & Downstream	General budget
Ireland	2005, 2010	✓	✓	✓	✓	59	62	0.23	Mid & Downstream	General budget,direct transfers, environmental spendin
Mexico	2014, 2020	✓	✓	✓	✓	61	4	0.02	Midstream	General budget
Japan	2010, 2011, 2012	✓	✓	✓	✓	77	2	0.05	Midstream	Environmental spending
Latvia	2004, 2005	✓	✓			25.4	79	0.39	Midstream	General budget
Liechtenstein	2005, 2008	✓	✓	✓	✓	81	130	0.60	Mid & Downstream	General budget
Luxembourg	2005, 2021	✓	✓	✓	✓	79	38	0.048	Mid & Downstream	General budget
Netherlands	2005, 2021	✓	✓			46	87	0.270	Mid & Downstream	General budget
Norway	1991, 2005	✓	✓	✓	✓	55	87	0.94	Mid & Downstream	General budget
Poland	1990, 2005	✓	✓	✓	✓	51	81	1.45	Mid & Downstream	Environmental spending
Portugal	2015, 2005	✓	✓	✓	✓	70	56	0.52	Mid & Downstream	General budget, environmental spending
Slovenia	1996, 2005	✓	✓	✓	✓	89	47	0.48	Mid & Downstream	General budget
Spain	2005, 2014	✓	✓		✓	37	82	0.25	Mid & Downstream	General budget, environmental spending
Sweden	1991, 2005	✓	✓	✓	✓	77	109	0.52	Mid & Downstream	General budget
UK	2013, 2021	✓	✓			49	67	0.42	Downstream	General budget, tax cuts
Switzerland	2008	✓	✓		✓	44	114	0.16	Midstream	Tax cuts, direct transfers, environmental spending