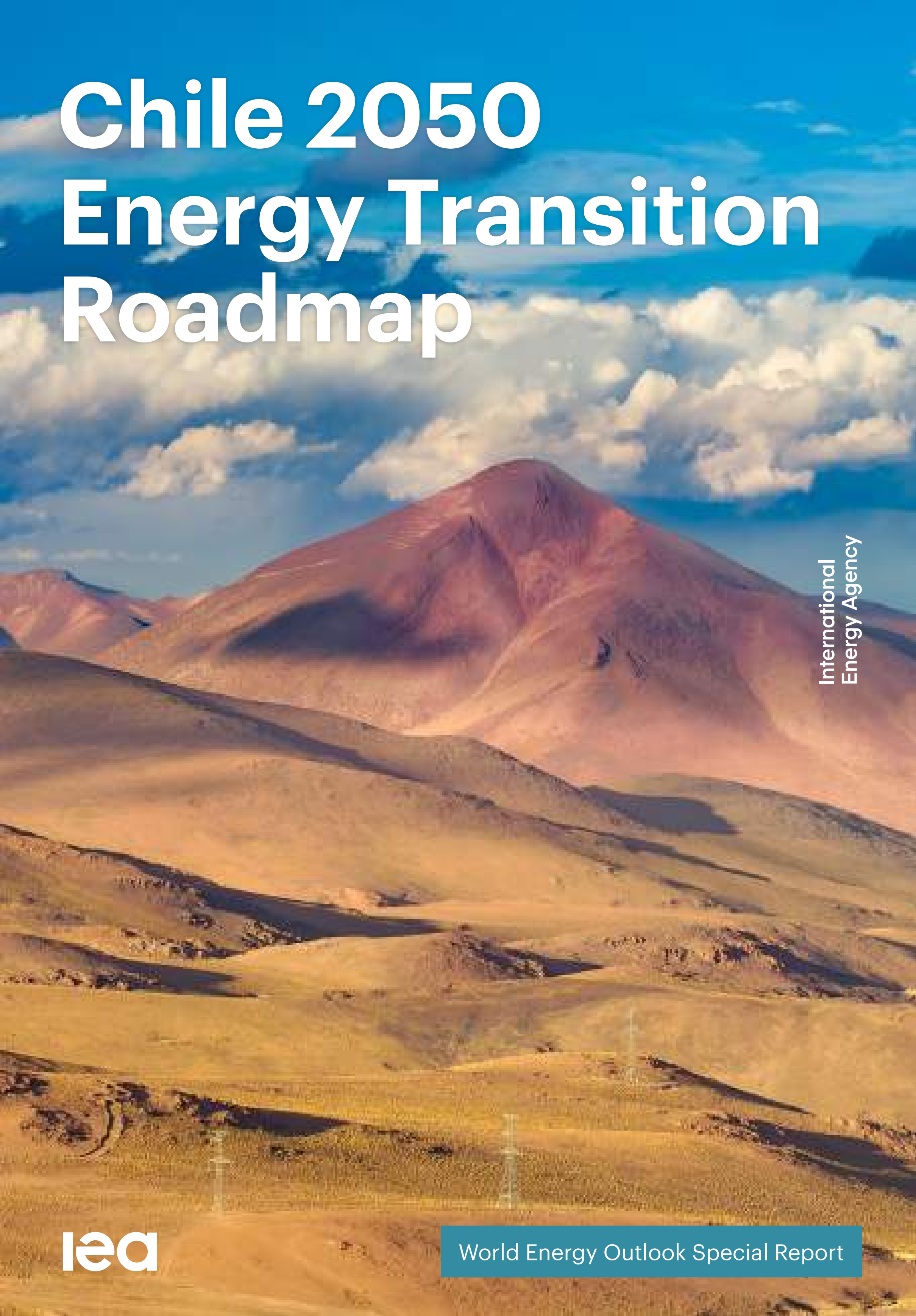

Chile 2050 Energy Transition Roadmap

International Energy Agency

World Energy Outlook Special Report

INTERNATIONAL ENERGY AGENCY

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Annexes

Chile’s natural resource endowment is key to its growth and to global security

Chile has achieved a sustained economic growth and poverty reduction trajectory. Its economy has grown steadily at an annual average rate of 2.6% since 2010. Mining remains the backbone of the economy, with copper and related industries accounting for around 50% of export earnings and 12% of GDP. Diversification efforts have increased exports of agricultural products, wine, forestry goods and seafood, but mining continues to dominate Chile’s economic landscape. While this dependence exposes Chile to global commodity cycles, it also positions the country to benefit from rising demand for critical minerals essential for clean energy technologies.

Chile has remarkable renewable and critical mineral resources; how they are used will shape the country’s future. Chile’s unique geography – stretching over 4 300 km from north to south – gives it exceptional renewable energy potential. The Atacama Desert boasts some of the world’s highest solar irradiance levels, while the Magallanes region offers wind resources that are among the best available anywhere. Chile ranks among the top global producers of critical minerals with around one-fifth of lithium supply, almost one-quarter of copper, and is the second-largest producer of molybdenum. These mineral resources, combined with world-class solar and wind, mean that Chile is well placed to play a key part in multiple supply chains.

Chile has already made significant strides in its energy transition. The share of low-emissions sources in total energy demand increased from 24% in 2010 to 38% in 2024, due in large part to coal power plant retirements and rapid deployment of solar PV and wind, which now provide over 34% of electricity generation. However, the economy continues to rely heavily on fossil fuels; Chile spent USD 14 billion on fossil fuel imports in 2024.

A pathway towards long term energy transition

At the request of the Government of Chile, the International Energy Agency (IEA) prepared this report to set out a roadmap for the energy sector as part of the completion of Chile’s net zero emission goal by 2050. It has been produced in close collaboration with the Ministry of Energy and is designed to serve as an input to the forthcoming elaboration of Chile’s Long-Term Energy Planning (PELP 2028-2032). This report builds on the modelling and analytical strengths of the IEA to assess what is needed to reduce energy-related emissions to reach net zero emission by 2050. It is based on the Announced Pledges Scenario (APS), in which Chile and all other countries meet their announced long-term net zero emissions targets.

The energy sector accounts for three-quarters of total greenhouse gas emissions in Chile. Energy-related CO_2 emissions peaked in 2019 at 94 Mt and have since fallen by more than 20% to 72 Mt in 2024. Chile’s Framework Law on Climate Change (2022) enshrines a legally binding target of carbon neutrality by 2050, and is reinforced by its updated Nationally Determined Contribution.

Successfully delivering on Chile's transition ambition relies on four key pillars

Meeting rising demand for energy services while supplying goods and services to global markets, cutting emissions and improving energy system resilience is a formidable challenge for Chile but requires substantial investment across the energy system. Success depends on four pillars: improving energy efficiency, decarbonising electricity generation, electrifying end-uses and developing resilient grids.

Energy efficiency is one of the most cost-effective levers for emissions reduction. In the APS, final energy intensity declines by 20% by 2035 and 45% by 2050. Material efficiency in industry, fuel economy in transport, and effective efficiency standards for building envelopes and appliances save households money and help to cut fossil fuel imports from USD 14 billion in 2024 to USD 10 billion in 2035 and USD 3 billion by 2050. Annual investment for end-uses sectors rises to over USD 3 billion – seven-times the 2015-2024 average – with the majority directed towards energy efficiency and electrification, particularly for transport.

The power sector is at the heart of decarbonisation plans. Renewables already account for close to 70% of electricity generation in Chile. In the APS, the renewables share rises rapidly, and more than 95% of electricity is generated from low-emissions sources by 2035. Solar PV and wind account for most new capacity additions, supported by storage and flexible resources to ensure reliability. The emissions intensity of electricity generation falls from 189 g CO_2/kWh today to just 29 g CO_2/kWh by 2035. This transformation is based on a rise in annual power sector investment from USD 3.5 billion in 2024 to USD 8 billion by 2035.

Electrification of transport, mining and heating is essential to cut emissions and improve air quality. In the APS, the share of electricity in total final consumption grows from 23% today to 55% in 2050, translating into an additional 80 TWh by 2050. Transport currently accounts for 60% of oil consumption in Chile. This changes in the APS, which sees electric vehicle (EV) sales reach nearly 100% by 2035 in line with the National Electromobility Strategy. In industry, mining companies are replacing mobile mining equipment with electric and hydrogen alternatives. For instance, the Escondida mine – the world's top producing copper mine – aims to fully replace its truck fleet with electric alternatives by 2033. In the buildings sector, energy demand for space heating more than halves by 2050 in the APS as heat pumps and better insulation become widespread.

Modern, resilient grids are the backbone of the transition. In the APS, grid length expands 40% by 2035 and more than triples by 2050, reaching 700 000 km, while increased digitalisation, automation and storage support the integration of variable renewables. Achieving this requires substantial investment; total average annual investment up to 2035 in electricity grids is projected to exceed USD 1 billion, which is double recent levels.

Building resilience into electricity systems is essential as climate risks intensify. Around 30% of Chile's grid is in areas prone to wildfires at least every ten years, and prolonged droughts threaten hydropower output. Adaptive measures – such as undergrounding lines, vegetation management and deploying advanced grid technologies – can reduce outage risks. Investment in resilience means upfront costs, but lowers recovery expenses and improves system reliability.

A just energy transition

Affordable energy transition is within reach. In the APS, total electricity system costs per unit fall by 15% between 2024 and 2035, even as power sector investment scales up. Household energy bills decline by more than 50% by 2050 compared to today, thanks to electrification and efficiency gains. Despite these savings, the high upfront costs of some clean energy technologies remain a barrier for adoption, especially to low-income households. Further policies and incentives, such as measures to reduce financing costs, are required to make these technologies more affordable and accessible.

Transition improves air quality. Air pollution is one of Chile's most pressing environmental and public health challenges, and is responsible for about 5 000 premature deaths each year, more than double the number of deaths from road traffic fatalities. Around half of households in Chile with heating needs use bioenergy, which accounts for more than three-quarters of residential heating demand. By 2050, bioenergy consumption for residential heating falls by 65% in the APS, thanks to more efficient use of bioenergy and a significant rise in electric heating, and this helps to reduce fine particular matter emissions and related premature deaths from air pollution.

A sustainable transition depends on ensuring that water needs are met. Desalination is increasingly being used to meet industrial and household water requirements, especially in the north of Chile, where copper and lithium deposits are concentrated. Changes in the climate and rising water needs mean that desalination capacity is expected to increase 2.5-fold by 2035. Reverse osmosis and other membrane-based electrified desalination technologies are up to ten-times more efficient than other technologies.

Chile's robust planning makes it a model for other economies seeking to reduce emissions. Its just transition plans aim to deliver ambitious climate goals alongside economic growth, and they incorporate policy design, market frameworks and stakeholder engagement. A comprehensive Just Energy Transition Strategy in Chile underpins its coal phase-out policy with the goal of minimising its socioeconomic impact on the communities that currently have coal power plants and ports that handle coal.

Clean energy transition offers opportunities for stronger economic growth

By 2040, the total value of Chile's critical minerals production could exceed USD 100 billion, amounting to one-fifth of the global total. Chile is the world's largest copper producer and among the largest lithium producers. Copper is essential for electricity grids, renewable energy systems and EVs, while lithium is a key component in batteries that power EVs and store renewable energy. Together, these minerals are fundamental to multiple parts of the global economy. In the APS, global copper demand rises 30% by 2035 and 50% by 2050, while lithium demand increases fourfold and sevenfold respectively. Without the addition of new projects beyond those already planned, copper production in Chile could peak and lithium output could plateau early in the 2030s. Despite this, Chile is set to remain a key long-term producer of copper and lithium in a world of rapidly rising demand.

There are opportunities for Chile to support technological innovation to enhance its role in the critical minerals supply chain. The National Lithium Strategy aims to move the country up the value chain and establish domestic refining and battery manufacturing. There are potential synergies between copper and lithium mining output in Chile and mining projects elsewhere in Latin America, given that the manufacturing process for many key energy technologies requires more than one critical mineral. These synergies could boost regional shared value creation.

New opportunities ahead for hydrogen exports

Chile's exceptional renewable resources mean that it is well placed to become a competitive supplier of low-emissions hydrogen. There is scope for low-emissions hydrogen to play a key role in decarbonising shipping, aviation and heavy industry globally by providing a clean alternative to fossil fuels in sectors that are difficult to electrify. Making use of both Chile's biogenic CO_2 resources and low-emissions hydrogen potential could enable it to become a competitive supplier of synthetic fuels. In the APS, electrolytic hydrogen generates USD 6 billion in export revenues for Chile by 2035 and USD 13 billion by 2050.

Developing domestic low-emissions hydrogen demand would help scale up its production and facilitate exports. Most announced low-emissions hydrogen projects in Chile have been shaped by expectations of future export opportunities amid limited domestic demand. Increased hydrogen deployment in Chile would help to underpin production and facilitate exports. There is scope for hydrogen to be used in Chile for methanol production, oil refining, transport, and heavy trucks and mobile equipment used in mining. In addition to existing industries, hydrogen could be used to stimulate local production of ammonia for fertiliser and mining explosives, reducing the need to import ammonia and its derivatives. In the APS, electrolytically produced ammonia in Chile is competitive with conventional technologies by 2035 in some regions of the country.

The path to net zero emissions lies firmly in the hands of policy makers in Chile

The transition modelled in the APS for Chile sets out a pathway, not the only pathway, to cut energy-related emissions in support of achieving its net zero emissions goal. In the APS, energy-related emissions fall from 72 Mt CO_2 in 2024 to 51 Mt CO_2 in 2035 and 16 Mt CO_2 in 2050. This represents a major contribution to its goal of net zero emissions by 2050, though it means that achieving net zero emissions overall by 2050 depends on offsets outside the energy sector, aligned with Chile's projected reduction in greenhouse gas emissions to achieve the carbon neutrality goal in the Framework Law on Climate Change.

Continued refinement of long-term energy plans, timely execution of grid and renewables projects, and bold measures to mobilise investment are crucial for success. The choices made will determine whether Chile is on course to achieve net zero emissions while boosting exports and reducing energy costs over time.

Purpose and scope

The *Chile 2050 Energy Transition Roadmap* aims to provide Chilean and international stakeholders with a clear outline of how Chile can achieve the goal of reaching net zero emissions by 2050 set out in its Framework Law on Climate Change in 2022. This report sets out a possible pathway for Chile's energy sector, in line with the country's overall 2050 goal and the requisite actions and investments. It is based on International Energy Agency (IEA) data, modelling and analysis, and is intended as an input to the forthcoming elaboration of Chile's next Long-Term Energy Planning (PELP 2028-2032).

The pathway set out in this report is not the only one possible for Chile to achieve net zero emissions for its overall economy. In common with other possible pathways, it depends on assumptions about policy implementation, technology costs and deployment, infrastructure development, macroeconomic dynamics and energy prices. These factors depend on wider global developments as well as what happens in Chile. For example, clean energy technology deployment in Chile will be affected by technology costs, and these costs will be influenced by the pace at which particular technologies are deployed in other countries.

The pathway discussed in this report is grounded in scenario analysis. It takes account of Chile's national and regional circumstances; up-to-date analysis of global markets for fuels and technologies; recognition of Chile's strategic priorities; and careful evaluation and analysis of the key drivers of its energy service demand.

Methodology and modelling approach

This report builds on three scenarios that have been modelled using the latest version of the IEA's Global Energy and Climate Model (GEC-M).[1] The modelling for this report was done in the context of the preparation of the IEA *World Energy Outlook-2025* (IEA, 2025a) and therefore uses a consistent modelling framework, encompassing macroeconomic developments, energy and climate policies, energy trade flows, and energy prices and technology costs.

The GEC-M is a large-scale and data-intensive global energy system simulation model which represents Chile individually within a connected framework of global energy markets. Much of the data on energy supply, transformation, demand and prices is obtained from the IEA databases of energy and economic statistics. The formal base year for this year's projections is 2023, because this is the most recent year for which a complete picture of energy demand and production is available. However, we have used more recent data wherever available, and we include our 2024 estimates for energy production and demand. Estimates for 2024 are based on the IEA *World Energy Balances* (IEA, 2025b), the latest monthly data submissions to the IEA Energy Data Centre, as well as recent market data from the IEA Market Report Series that cover coal, oil, natural gas, renewables and power.

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[1] https://www.iea.org/reports/global-energy-and-climate-model

The GEC-M covers all sectors across the energy system from energy service and material demand to energy supply and primary energy demand. It includes details about stocks of energy-consuming appliances and equipment across end-use sectors, and uses dedicated bottom-up modelling to assess final energy consumption across industry, transport, buildings, agriculture and other non-energy uses. Its coverage of energy transformation encompasses multiple sectors and features a dedicated power sector model (including electricity generation, heat production, transmission and distribution networks and storage systems), a dedicated model for hydrogen and hydrogen-based fuels, and coverage of other energy-related processes such as refineries and the production of biofuels. Its comprehensive coverage of energy supply includes both fossil fuel and renewable energy resources. It calculates investment and fuel costs for various sectors and technologies, and in aggregate for the whole energy system (IEA, 2025c). It assesses the development of global trade for conventional fossil fuels, emerging hydrogen and hydrogen-based fuels, critical energy minerals and bioenergy; and it includes trends in access to electricity and clean cooking, and the impact of the energy sector's evolution on employment in the sector.

Scenario design

Chile has set a target to achieve net zero greenhouse gas (GHG) emissions by 2050. This goal is reflected in this report's central scenario – the **Announced Pledges Scenario** (APS). The APS assumes that all governments will meet, on time and in full, all announced climate-related commitments, including longer term net zero emissions targets and pledges in National Determined Contributions (NDCs), as well as commitments in related areas such as energy access. Pledges made by businesses and other stakeholders are also taken into account where they add to the ambition set out by governments. Although Chile's overall economy reaches net zero emissions by 2050 in the APS, the scenario does not imply that the energy sector on its own reaches net zero GHG emissions by this date.

Two additional scenarios are referred to in this report to provide context for the net zero pathway in the APS. By modelling differing levels of implementation of global climate targets, these scenarios help expand the range of projections for production and exports of critical minerals and of low-emissions fuels such as hydrogen. The **Stated Policies Scenario** (STEPS) is a less ambitious scenario than the APS and does not assume that aspirational long-term goals, such as those included in some NDCs, will be achieved. Instead, it is designed to reflect the prevailing direction of travel for the energy system, based on a detailed reading of country-specific energy, climate and related industrial policies that have been adopted or put forward, even if not yet codified in law. In addition, the STEPS assumes that continued progress is made in addressing and overcoming deployment challenges and barriers for new technologies. The **Net Zero Emissions by 2050** (NZE) **Scenario** provides a more ambitious reference point. It presents a possible pathway for the global energy sector to achieve net zero carbon dioxide emissions by 2050 that is consistent with a long-term goal of limiting the rise in global average temperatures to 1.5 degrees Celsius (°C) (with a 50% probability). The NZE Scenario assumes a significant degree of international collaboration to demonstrate, commercialise and diffuse key low-emissions technologies on an accelerated timeframe, leading to lower costs of clean energy technologies than in other scenarios. In addition, the NZE Scenario does not rely on offsets outside the energy sector, as many national net zero emissions pledges do, meaning that the energy sector must decarbonise more rapidly than envisaged in many national net zero plans. As a result, energy-related emissions in 2050 are lower in the NZE Scenario than in the APS in most countries, including Chile.

Structure

Chapter 1 provides an overview of the current energy landscape in Chile, including key trends in supply and demand, the energy mix, and the policy environment shaping energy development.

Chapter 2 presents a detailed, sector-by-sector analysis of the energy transition roadmap, beginning with an assessment of total energy demand and covering end-use sectors – transport, industry and buildings – as well as the power sector and the role of fuels such as oil, gas, coal and bioenergy.

Chapter 3 explores the broader implications of the energy transition roadmap, focusing on emissions reduction, investment needs, affordability, energy security and air pollution.

Chapter 4 explores three central dimensions of Chile’s energy transition:

- The potential value to Chile of low-emissions hydrogen both for domestic use and for export markets.
- The importance of Chile’s critical minerals resources in the context of global demand trends, and strategies for maximising their value.
- The need to strengthen climate resilience in the power sector through risk assessment and adaptive measures.

Chapter 1

Chile's energy sector today

A transforming landscape

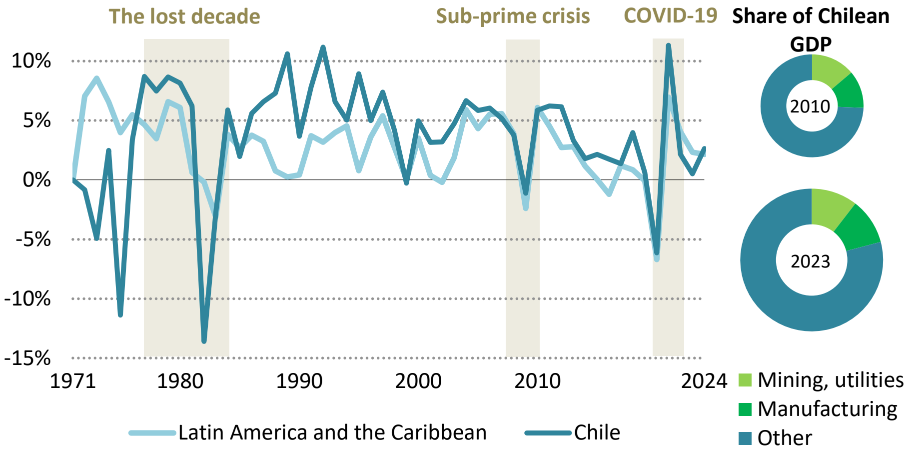
SUMMARY

- Chile has a predominantly urban population of 20.1 million and its economy has grown by an average of 2.6% annually since 2010. The strategically important mining sector accounts for around 12% of gross domestic product. Chile has exceptional renewable energy potential, notably in the Atacama Desert, which has some of the world's highest solar irradiance levels, and in the Magallanes region, which has high capacity factors for wind. There is scope to harness this potential for clean energy development.
- The share of fossil fuels in total energy demand in Chile as fallen from 78% in 2010 to 64% in 2024. Most fossil fuels are imported, at a cost of around US dollars 14 billion in 2024. Oil – the largest energy source – accounts for 43% of total energy demand. Bioenergy is the second largest source, reflecting the use of wood for household heating in the south of the country. Solar and wind energy have grown rapidly in recent years and accounted for 7% of total energy demand in 2024.
- Total final consumption (TFC) in Chile reached around 1 300 petajoules in 2024. In the end-use sectors, oil accounted for 53% of final consumption and electricity for 23%. Industry, dominated by mining, was responsible for 38% of TFC, transport for over 30%, and buildings for most of the remainder.
- Electricity demand in Chile has increased by 3.1% annually since 2010. Since 2015, solar photovoltaics (PV) and wind have driven new capacity additions, and solar PV accounted for 23% of generation in 2024. Hydropower supplied 29% of electricity in 2024 and is a critical dispatchable source, while natural gas is crucial for balancing supply. Coal-fired power peaked in 2016 and has declined 56% by 2024.
- The energy sector accounts for three-quarters of total greenhouse gas emissions in Chile. Carbon dioxide emissions from the energy sector peaked in 2019, and have since declined by roughly 20%, thanks in large part to early retirement of coal power plants. Air pollution remains a serious challenge with 90% of Chileans being exposed to polluted air, and around 10% to heavily polluted air. In 2024, more than 5 000 people in Chile died prematurely from exposure to ambient air pollution, more than double the number of deaths from road traffic fatalities.
- The national decarbonisation strategy is set out in the 2022 Framework Law on Climate Change, which legally binds Chile to achieve net zero emissions by mid-century, with significant contributions from land-use change and forestry. The updated Nationally Determined Contribution adopted by the Council of Ministers in June 2025 aims for a peak in greenhouse gas emissions by 2025.

1.1 Overview and socioeconomic context

Chile is a mountainous country on South America's western coast, stretching over 4 300 kilometres (km) from north to south while averaging only 177 km in width. With a median age of 36.9 years and population of 20.1 million in 2024, Chile ranks as the seventh most populous country in the Latin America and the Caribbean (LAC) region. Chile is highly urbanised: 88% of the population lives in urban areas, of which about 40% live in and around the capitol of Santiago. The far northern and southern parts of the country are sparsely populated, reflecting their challenging climate conditions.

Figure 1.1 ▹ Annual rate of change in GDP in LAC and in Chile, 1971-2024, and share of GDP by sector in Chile, 2010 and 2023



IEA. CC BY 4.0.

After contracting in the early 1980s, Chile's economy has grown steadily, with average GDP growth of 2.6% since 2010, pausing only during the COVID-19 pandemic

Note: GDP = gross domestic product.

Source: IEA analysis based on IMF (IMF, 2025). Other includes agriculture, forestry, fishing, construction, wholesale, retail trade, restaurants, hotels, transport, storage, communication and other activities.

Economic growth in Chile has been steady since the 2000s, averaging 2.6% annually since 2010 (Figure 1.1). Chile is a founding member of the World Trade Organization, and has trade agreements in place with economies representing almost 90% of global gross domestic product (GDP). Its economy remains heavily dependent on copper mining and related services and industries, which together account for approximately 50% of export earnings and 12% of GDP. As a result, domestic growth prospects are significantly affected by mining output plus international mineral price and trade fluctuations, as for example when the financial crisis of 2008 hit demand for commodity exports. However, Chile has been diversifying its export base to include agricultural products, wine, forestry products and seafood.

Chile has made notable progress to reduce poverty in recent decades. The proportion of the population living in poverty declined from 36% in 2000 to 6.5% in 2022, which is one of the lowest rates in Latin America.

Table 1.1 ⊳ Key indicators for Chile, 2000-2024, and in LAC, 2024

	Chile			LAC 2024
	2000	2010	2024	
Population (millions)	15.3	17.1	20.1	669
GDP (billion USD [2024, PPP])	308.8	471.0	678.0	14 171
GDP per capita (USD per capita, [2024, PPP])	20 127	27 600	33 785	21 197
Urbanisation	86%	87%	88%	82%
Poverty rate	36%	25%	7%	n.a.
Inequality (GINI)	52.8	47.4	43.0	n.a.
Global gender gap	-	70%	78%	n.a.
Electricity access rate	97%	99%	100%	98%
Clean cooking access rate	100%	100%	100%	90%
Total energy demand (PJ)	1 052	1 280	1 679	38 348
Total energy demand per capita (GJ)	68.5	75.0	83.7	57.4
Energy intensity (MJ per USD, PPP)	3.41	2.72	2.48	2.71
Share of fossil fuels in total energy demand	75%	78%	64%	66%
Share of renewables in electricity generation	49%	40%	69%	63%
Oil import dependency	96%	96%	98%	n.a.
Gas import dependency	70%	64%	79%	n.a.
Energy sector CO_2 (Mt CO_2)	52.7	71.5	72.1	1 700
Carbon intensity of total energy demand (t CO_2/TJ)	50.13	55.85	42.91	44.33

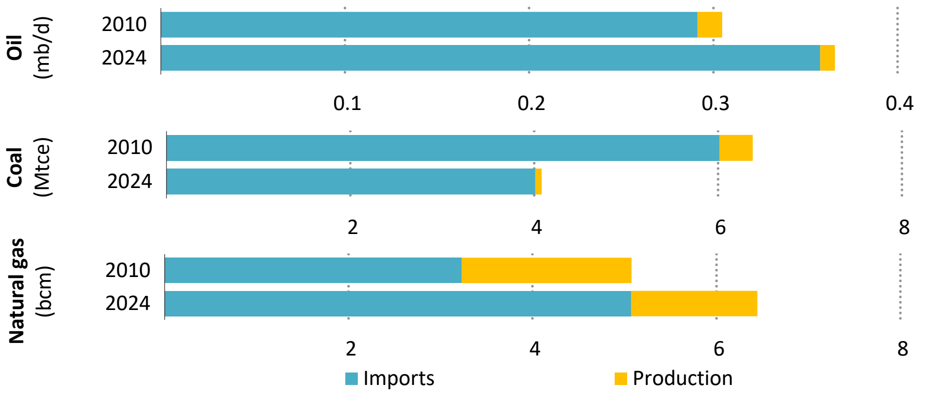
Notes: LAC = Latin America and the Caribbean; USD = US dollar; PPP = purchasing power parity; PJ = petajoule; GJ = gigajoule; MJ = megajoule; Mt CO_2 = million tonnes of carbon dioxide; t CO_2/TJ = tonnes of carbon dioxide per terajoule. Oil and gas import dependency = net imports / demand. The GINI coefficient measures how much the distribution of income among individuals or households deviates from a perfectly equal distribution. A value of 0 represents absolute equality, whereas 100 represents the highest possible degree of inequality. Poverty rate is measured in percentage points over 100% of the population and is the proportion of the total population living on less than 4.2 USD per day (2021 PPP). Poverty rate and GINI values for 2024 correspond to the 2022 value and for 2010 to the 2009 value. Global gender gap is calculated using the averages of the indicators of each dimension, based on ratios between estimated values of each category by gender; for the overall index, the highest possible value is 1, reflecting total equity, while 0 represents total inequity.

Sources: OECD (2025); IMF (International Monetary Fund) (2025); World Bank (2025a); World Bank (2025b); WEF (World Economic Forum) (2025); WEF (2010).

A rich natural endowment in both renewable energy potential and critical mineral reserves, means that Chile has the potential to play a major role in the global energy transition. Chile is the world's top copper producer with 24% of output in 2024, and also ranks among the top lithium suppliers with around one-fifth of global production. Copper is essential for a wide range of electric technologies, notably grids and lithium for batteries. Increasing electrification worldwide is spurring demand for grids and batteries which could boost mining revenues in Chile: global lithium demand is set to grow fivefold in the period to 2040, and copper demand is projected to grow by 30% (IEA, 2025a). As set out in the National Lithium Strategy, Chile aims to develop its lithium industry and move from a purely commodity-based export model to one where value is added domestically, e.g. through refining minerals, manufacturing battery components, and investing resource revenues in economic diversification initiatives (Government of Chile, 2023).

In addition, Chile has exceptional renewable energy potential, notably in the Atacama Desert, which has some of the world's highest solar irradiance levels, and in the Magallanes region, which has high capacity factors for wind power. There is scope to do much more to harness this potential at low cost. Doing so would reduce the current dependence on energy imports and boost energy security: imported fossil fuels cost around US dollars (USD) 14 billion in 2024, and accounted for about 61% of its primary energy demand, exposing Chile's energy system to external shocks and global price volatility (Figure 1.2).

Figure 1.2 ▷ **Fossil fuel imports and production in Chile, 2010-2024**



IEA. CC BY 4.0.

Chile has limited domestic fossil fuel production and relies heavily on imports of oil, natural gas and coal to meet its energy needs

Note: mb/d = million barrels per day; Mtce = million tonnes of coal equivalent; bcm = billion cubic metres.

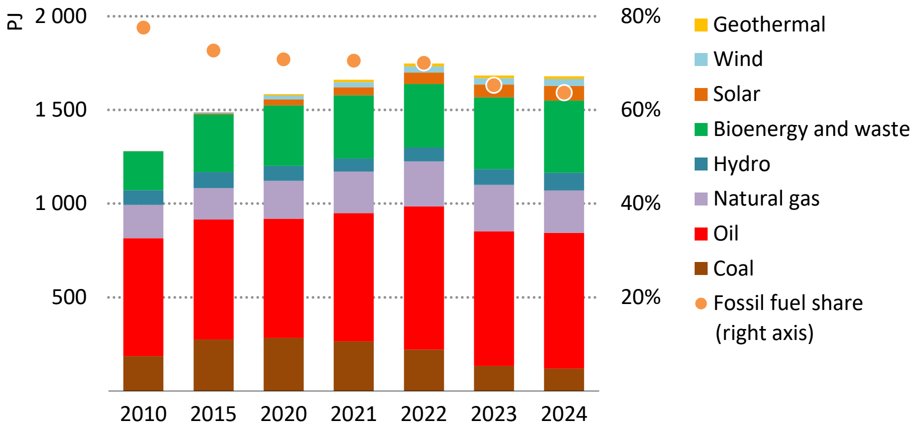
Sources IEA (2025b) and IEA estimates for 2024.

1.2 Overview of current energy mix and emissions

1.2.1 *Total energy demand*

While Chile remains substantially reliant on fossil fuels, its energy landscape has changed significantly in recent years. The share of fossil fuels in total energy supply has dropped from almost 80% in 2010 to close to 60% in 2024, driven primarily by reductions in the power sector (Figure 1.3). The fossil fuel share in total final consumption remains virtually the same as in 2010 at around 62%.

Figure 1.3 ▹ **Energy demand by source in Chile, 2010-2024**



IEA. CC BY 4.0.

Oil accounts for over 40% of total energy demand. The share of fossil fuels in demand has decreased in recent years, but they still account for more than 60% of the total

Note: Oil includes primary and secondary oil.

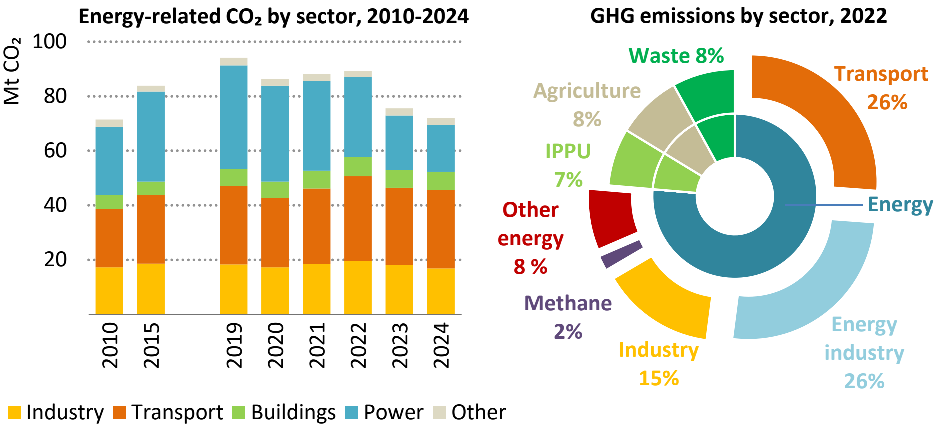
Sources: IEA (2025b) and IEA estimates for 2024.

Oil is the single largest energy source in Chile, accounting for 43% of total energy demand, of which 98% is imported. Natural gas accounts for around 14% of demand: most of it is imported through two liquefied natural gas (LNG) terminals or by pipeline from Argentina. Coal now accounts for only 7% of total energy demand, a significant drop from its 20% market share in 2019. Bioenergy – mainly in the form of firewood for residential heating – accounts for almost one-quarter of energy demand: it is used in particular in southern regions, where up to 90% of rural households rely on wood for heating. Biogas demand has expanded in the last decade, but it still accounts for only 1% of overall bioenergy and waste demand. Solar and wind energy have experienced rapid growth from less than 1% of demand in 2015 to 7% in 2024.

1.2.2 Emissions and air pollution

Energy-related and industrial process carbon dioxide (CO_2) emissions in Chile, which account for around three-quarters of its total greenhouse gas (GHG) emissions, peaked in 2019. By 2024, they were roughly 20% below this peak, driven down by the early retirement of coal plants (Figure 1.4). The transport sector is responsible for about 40% of emissions. Power generation and industry, more than half of which is mining, account for approximately 25% each.

Figure 1.4 ▹ Energy-related CO_2 and GHG emissions by sector in Chile


Energy-related CO_2 by sector, 2010-2024

GHG emissions by sector, 2022

IEA. CC BY 4.0.

Energy-related emissions account for three-quarters of Chile's total GHG and peaked in 2019

Notes: IPPU = industry processes and product use. Other includes agriculture and other energy sector.

Sources: IEA (2025c); MMA (2024).

Roughly 90% of Chileans are exposed to polluted air, and around 10% to heavily polluted air, with major consequences for health.[1] Air pollution is severe: the national average fine particulate matter ($PM_{2.5}$) concentration in 2024 was around 17 microgrammes per cubic metre (µg/m^3), more than three-times the World Health Organization (WHO) guideline level of 5 µg/m^3 (IQAir, 2025). In 2024, more than 5 000 people in Chile died prematurely from exposure to air pollution, more than double the number of deaths from road traffic fatalities. In addition to its heavy toll on public health, air pollution hinders economic growth by raising healthcare costs, reducing productivity and increasing early retirements.

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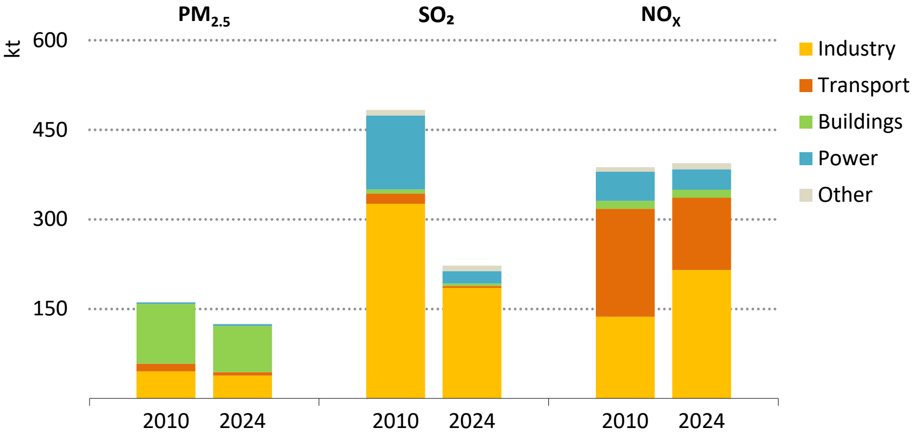
[1] Polluted air and heavily polluted air correspond to having a $PM_{2.5}$ density greater than 5 µg/m^3 and 35 µg/m^3 respectively.

Regional disparities are pronounced, especially in winter months when wood burning and dust from construction, agriculture and unpaved roads exacerbate particulate pollution, disproportionately affecting lower income communities that rely on biomass use for heating. Antofagasta in northern Chile experiences high levels of emissions of pollutants from large-scale mining activities and industrial plants, whereas air pollution in Valparaíso in central Chile emanates from a mix of transport, industry and household burning of wood. Temuco in southern Chile suffers severe winter episodes of $PM_{2.5}$ air pollution as a result of residential wood heating, with cultural and economic barriers impeding the adoption of cleaner alternative fuels.

Figure 1.5 ▷ Pollutant emissions by sector in Chile, 2010 and 2024



IEA. CC BY 4.0.

$PM_{2.5}$ and SO_2 emissions have declined since 2010, but NO_X emissions have remained flat

Notes: kt = kilotonne; $PM_{2.5}$ = fine particulate matter; SO_2 = sulphur dioxide; NO_X = nitrogen oxides. Other includes agriculture and other non-energy use.

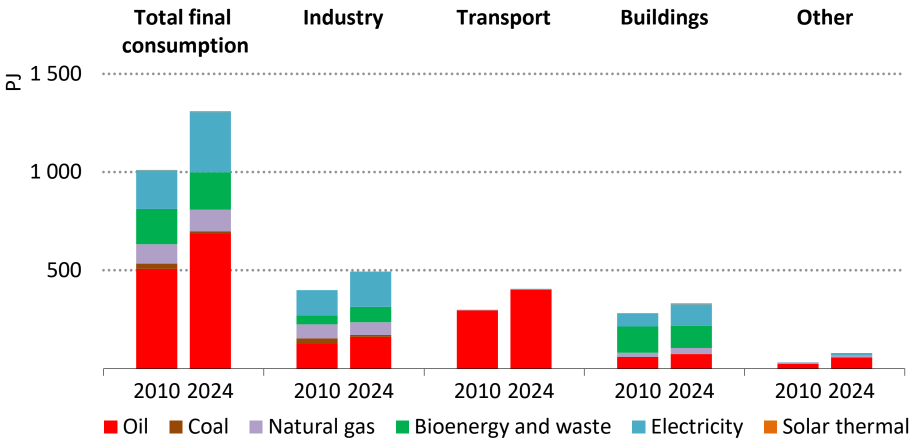
Source: IEA analysis based on International Institute for Applied Systems Analysis (IIASA).

1.2.3 Total final consumption

Total final energy consumption in Chile was approximately 1 300 petajoules (PJ) in 2024, with fossil fuels accounting for around 60% (Figure 1.6). Oil accounted for 53% of the total and electricity for 23%.

Industry was the largest end-use sector with 38% of demand, followed by transport at over 30%, with the buildings sector responsible for most of the remainder. Oil accounted for nearly 100% of energy consumption in transport, making the sector responsible for around 60% of total oil consumption. Industry accounted for almost a quarter of oil consumption, with mining trucks and machinery responsible for two-thirds of industrial oil use.

Figure 1.6 ▷ **Total final consumption by sector and source in Chile, 2010-2024**



IEA. CC BY 4.0.

Fossil fuels continue to play a major role across all end-use sectors

Note: Other includes agriculture and other non-energy use.

Sources: IEA (2025b) and IEA estimates for 2024.

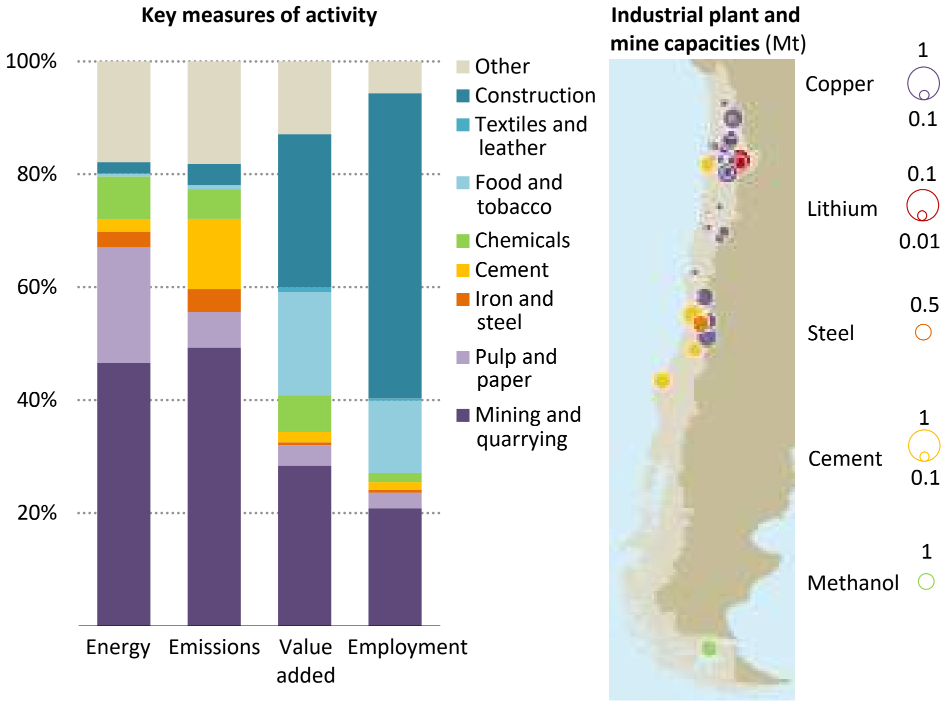
Industry

Industry is the largest energy end-use sector in Chile, accounting for 38% of total final consumption of energy in 2024. By far, mining is the largest industrial sub-sector. Chile is the largest miner of copper in the world. It is also a major producer of molybdenum and lithium, with co-production of multiple metals from some ores allowing secondary sources of revenue to be obtained from a single mine site. Mining is set to remain a crucially important industry, though it faces some climate-related risks, with over 80% of its copper mines located in areas of water stress.

Direct emissions from industry peaked in 2022 at around 20 million tonnes of carbon dioxide (Mt CO_2), but have since fallen by 2.5 million tonnes (Mt), despite energy use increasing by 3% since 2022, and the economic value added by industry expanding by almost 6%. Oil is the largest fossil fuel source used in industry, supplying around a third of its energy demand. Its consumption peaked in 2022, and the subsequent decline in oil use has driven the decline in emissions. Electrification, improved energy efficiency and increasing use of bioenergy have all played a part in slowing the growth of fossil fuels. Further emissions reductions will depend to a large extent on continuing reductions in demand for oil, particularly in the mining sector.

Chilean copper mines are concentrated in the north, while heavy industries like steel and cement are mostly located near Santiago. Steel and cement represent a relatively small component of industrial energy demand compared to global averages, particularly since the closure of the Huachipato steel plant in 2024, leaving the region without primary pig iron production. Except for the Methanex methanol plant, the south of Chile does not currently have any large heavy industrial facilities, but its natural wind resources in the Magallanes region could provide the basis for future electrolytic hydrogen industry.

Figure 1.7 ▹ Key measures of industrial activity and locations of major industrial facilities in Chile, 2023



IEA. CC BY 4.0.

Copper is Chile's largest industry with 36 mines spread across the north of the country; other industry sub-sectors tend to be more geographically concentrated

Notes: Mt = million tonnes. Only one methanol and one steel plant are operating in Chile, since closure of the Huachipato steel plant in 2024. Key measures of activity are shown for 2023, the last year for which all data are available.

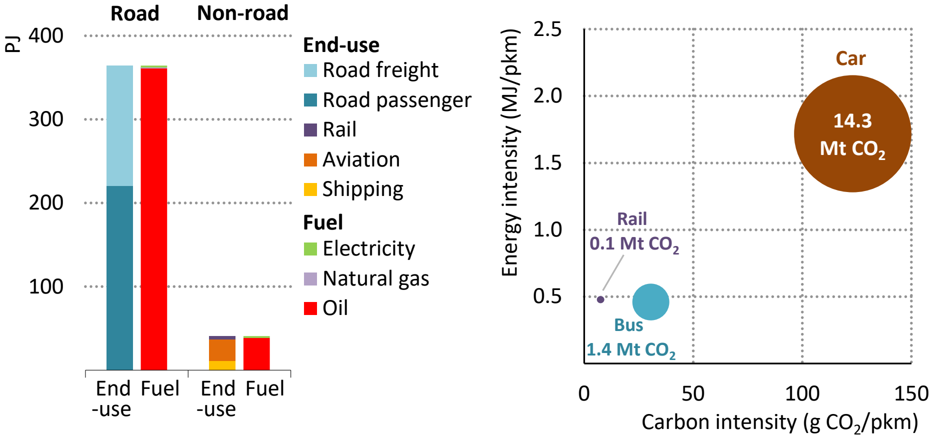
Sources: IEA analysis based on Global Energy Monitor (2025); IEA (2023); Instituto Nacional de Estadisticas (National Institute of Statistics) (2025).

As in many countries, the energy and emissions associated with industry sectors do not always correspond to their contribution to the economy (Figure 1.7). Mining accounts for 47% of industrial energy and 28% of industrial value added. Conventional energy-intensive industries, which include iron and steel, cement, chemicals, non-ferrous metals, and pulp and paper, consume 34% of industrial energy while contributing only 13% of industrial value added. By contrast, the construction sub-sector direct energy demand and emissions are small, but it adds significant employment and value to the economy.

Transport

Transport accounts for over 30% of total final consumption of energy in Chile and nearly 60% of its total oil consumption. Road passenger transport is responsible for more than half of transport energy consumption, of which nearly 100% is currently met by oil (Figure 1.8).

Figure 1.8 ▷ Transport sector energy consumption, and energy and carbon intensity of passenger transport modes in Chile, 2024



Railways and buses depend on oil, just as private cars do, but they are less energy-intensive and less carbon-intensive than cars

Notes: MJ/pkm = megajoules per passenger-kilometre; g CO_2/pkm = grammes of carbon dioxide per passenger-kilometre. Bubble size is proportional to total CO_2 emissions from each mode type.

Urban transportation plays a crucial role in Chile, which is one of the most highly urbanised countries in the world, with around 88% of the population living in urban areas. Santiago metropolitan region alone is home to about 40% of Chile's inhabitants, and high average incomes in the city mean higher levels of car ownership and usage than elsewhere in the country. At the same time, urban density fostered development of public transport services, which are becoming increasingly electrified. Nearly 15% of new bus sales were electric in 2024, which is one of the highest market shares in Latin America (IEA, 2025d).

Santiago has one of the largest urban electric bus fleets in the world. The city aims for electric buses to make up 70% of its fleet by early 2026 and has developed a plan to upgrade the transportation network, with co-financing provided by the state. Santiago's progress has been built on public-private partnerships and innovative tendering mechanisms that require 50% of bus fleets to be electric. Electric bus networks are also being developed in Valparaíso, Concepción, Antofagasta, Coquimbo-La Serena, Colina, Rancagua, Puerto Montt and Copiapó, which is the first city in the country with a 100% electric public transport bus fleet.

In Santiago, the "Restricción vehicular 2025" road rationing policy and expansion of metro lines and cycle lanes are encouraging the use of transport options other than private cars. Together with electrification of the bus fleet and adoption of tougher fuel economy standards (see Chapter 2), these measures are helping to reduce oil dependency in road transport while diversifying mobility options.

Since 2015, shipping activity in Chile has increased by 3%, passenger rail by 17%, road freight by 10% and domestic aviation by nearly 70%. Of all the passenger transport modes, rail has the lowest carbon intensity at 8 grammes of carbon dioxide per passenger-kilometre (g CO_2/pkm) and is 16-times more efficient than cars. Nearly all of aviation, shipping and road freight demand is currently met by oil. However, recent policy initiatives aim to reduce dependency on oil in the aviation sector, e.g. the Sustainable Aviation Fuel Roadmap, in the shipping sector, e.g. signing of the Clydebank Declaration[2] in 2021, and in the road freight sector, including through commitments to tighten fuel economy standards for trucks, and measures to encourage the electrification of freight in the Electromobility Strategy and Roadmap.

Buildings

Buildings account for a quarter of total energy consumption in Chile. Energy use in buildings has grown at an average annual rate of 1.2% since 2010. Electricity and solid biomass each meet around a third of demand, with oil and gas making up most of the remainder (Figure 1.9).

A large proportion of the population lives in regions where homes need to be heated for some of the year, particularly in the colder central and southern zones. This makes space heating the main energy end-use in buildings, accounting for around 40% of energy consumption. Gas distribution networks supply nearly a million households for space and water heating. However, many households rely on the combustion of solid biomass in the form of firewood for heating. Rural households are particularly dependent on biomass: they used 40% of the solid biomass burned in homes in 2023, despite making up only 12% of the population. As well as causing air pollution, firewood is an inefficient way to provide heat. Chile has introduced several measures to improve biomass-based heating efficiency (see Annex B, Table B.5).

Electricity is widely used in both residential and services buildings. In households, appliances account for most electricity demand. Cooling needs are relatively low, and there is limited electrification of heating. However, cooling demand is on the rise, especially in northern and central parts of the country, driven by higher temperatures and growing incomes. Electricity is the main energy source in the services sub-sector, where it is primarily used for appliances, lighting and desalination. Limited freshwater resources in parts of Chile, particularly in the

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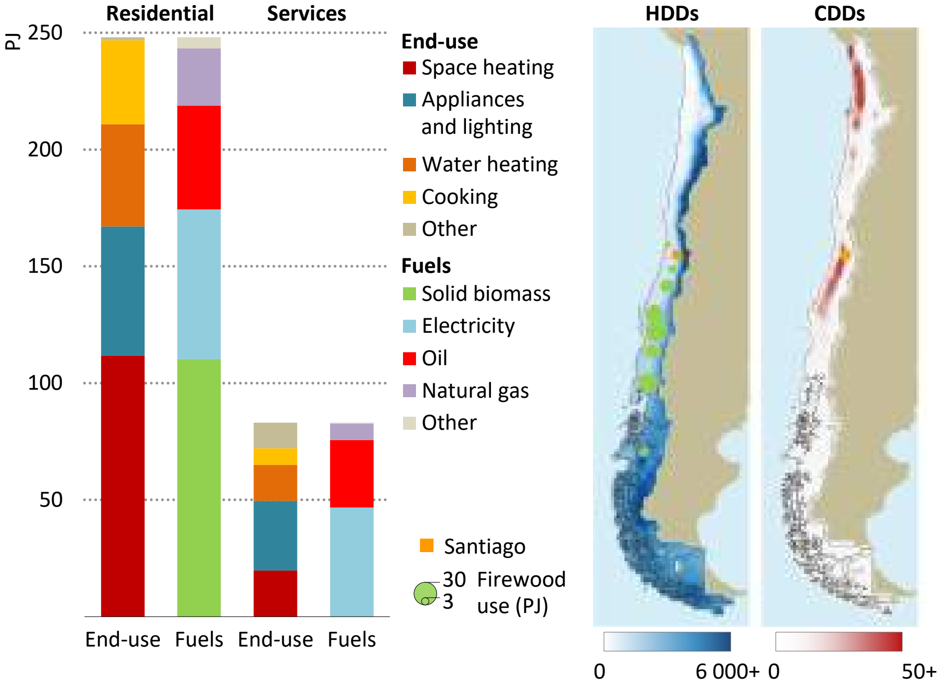
[2] The Clydebank Declaration has a collective aim to support the establishment of green shipping corridors and has been signed by 28 countries.

north, means that the use of desalination is increasing, and accounts for a growing share of electricity use in the buildings sector.

Figure 1.9 ⊳ Energy demand in buildings by fuel and end-use, and heating and cooling needs in Chile, 2024



IEA. CC BY 4.0.

Space heating accounts for 40% of energy consumption in buildings, much of which currently comes from solid biomass

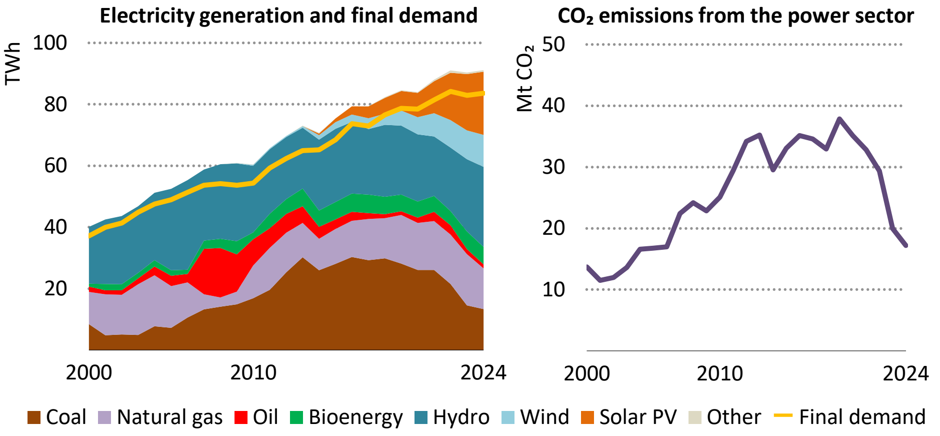
Notes: HDDs = heating degree days using a threshold of 16 °C; CDDs = cooling degree days using a threshold of 21 °C. The mapped degree days are averaged over 2020-2024. For context, in 2024 the United States population had on average 1 460 HDDs and 550 CDDs. Other end-use includes desalination, space cooling and data centres. Other fuels include solar thermal and biogas. Firewood in the right chart is based on Instituto Forestal (INFOR, 2023) estimates for 2023. The firewood circles are centred in each corresponding administrative region.

1.2.4 Power sector

Chile's electricity system has undergone a profound transformation over the past two decades, driven by a combination of structural market reforms, increasing demand and a strong policy push toward decarbonisation and resilience. Underpinned by economic development and population growth, electricity demand increased by 3.1% a year since 2010, compared with an average of 2.2% across the Latin America and the Caribbean region, reaching 84 terawatt-hours in 2024. Per capita electricity consumption is higher in Chile than the LAC average: electricity demand per capita was 4.2 megawatt-hour per capita (MWh/capita) in 2024, compared to an average of 2.3 MWh/capita for the LAC region. This represents a 31% increase in Chile from the 2010 level of 3.2 MWh/capita.

In the early 2000s, the electricity mix in Chile was dominated by hydropower and natural gas (Figure 1.10). From the mid-2000s, Chile diversified its electricity mix in response to repeated droughts and disruption to gas imports. This led to a subsequent rise in coal use and a short-lived shift from gas- to oil-fired generation after 2005. In the 2010s, coal-fired generation overtook gas and hydropower as the main source of electricity. However, cost pressures, increasing environmental concerns and public opposition led to an agreement between the Ministry of Energy and the companies concerned in 2019 to phase out coal use in power generation by 2040 (see Annex B). Coal-fired power peaked in 2016 and has declined 56% by 2024.

Figure 1.10 ▷ Electricity generation and final demand, and CO_2 emissions from the power sector in Chile, 2000-2024



IEA. CC BY 4.0.

From the 2000s to the mid-2010s, the growth of electricity generation was largely driven by the rise of coal-fired power

Note: TWh = terawatt-hour.

The 2024 Decarbonisation Plan sets out specific actions to phase out the remaining 3.8 gigawatts (GW) of installed coal capacity while ensuring energy security (Ministerio de Energía, 2024). It includes measures to support the rapid deployment of renewables through renewable energy auctions, market-driven policy incentives and the development of battery storage, which gained momentum in 2023 amid rising curtailment rates and declining battery pack costs.

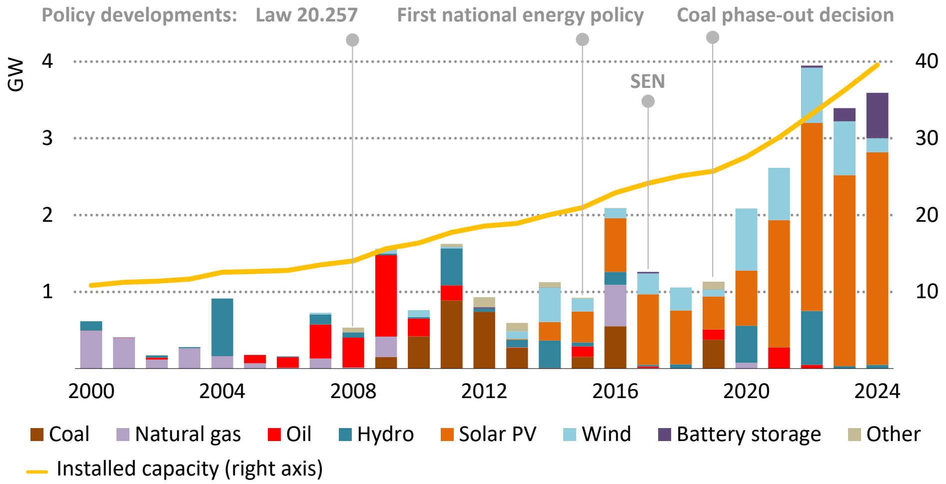
In recent years, solar photovoltaics (PV) emerged as the fastest-growing source of electricity in Chile. By 2024, solar PV accounted for 23% of the generation mix, one of the highest shares in the world. The rise of solar PV has contributed to a marked decline in emissions from the power sector since 2022, which in 2024 declined to levels last seen in 2006.

Hydropower accounted for 29% of electricity generation in 2024, remaining a key renewable and dispatchable source in the power mix. However, recurring droughts in recent years have impacted hydro generation and raised concerns about reliability.

Natural gas continues to play a balancing role, with supply largely dependent on LNG imports and pipeline imports from Argentina. Chile operates two LNG terminals: Quintero, serving central Chile and power plants near Santiago; and Mejillones, supplying the mining-intensive north of the country.

Since 2013, renewables have dominated capacity additions (Figure 1.11). Law 20.257 in 2008 put in place a mandate for minimum shares of renewable in the generation mix, and the target for renewables to reach 20% of total power capacity by 2025 has been achieved. Transmission grids have expanded, connecting remote renewables-rich areas to demand centres and reducing curtailments.

Figure 1.11 ⊳ Capacity additions by type and total installed capacity, and major policy development timelines in Chile, 2000-2024



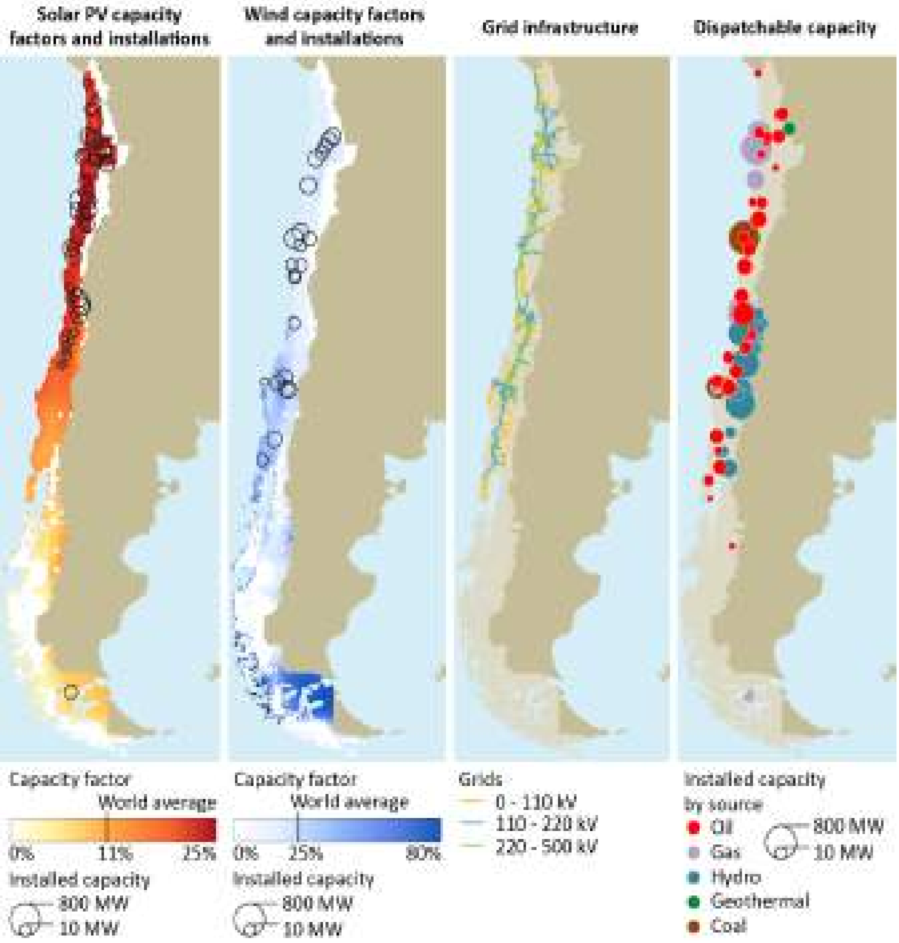
IEA. CC BY 4.0.

Solar PV and wind accounted for the majority of new capacity additions each year since 2014

Note: GW = gigawatt; SEN = national electricity system.

Chile’s geography led to the development of three separate electricity systems: the National Electricity System (SEN), which extends from the Arica and Parinacota region to the Los Lagos region, and is responsible for meeting the largest share of electricity demand; the Aysén Electricity System (SEA) and the Magallanes Electricity System (SEM), both of which are in the south of the country. The SEN stretches over 3 100 km and was formed in 2017 through the interconnection of the former central (SIC) and northern (SING) systems, enabling greater system flexibility and renewables integration (Figure 1.12).

Figure 1.12 ▷ Renewables potential for solar and wind resources, and today’s electricity system in Chile



IEA. CC BY 4.0.

With excellent solar resources in the north and wind resources in the south, Chile has some of the best renewable potential in the world

Note: kV = kilovolt; MW = megawatt.

Chile – a pioneer in electricity market liberalisation – established a marginal cost-based wholesale spot market in 1982. The Coordinador Eléctrico Nacional (CEN), created in 2016 as a combination of existing institutions, serves as the independent system operator, ensuring secure and economically efficient operations and non-discriminatory grid access.

Chile has made significant progress to assess the resilience of its electricity systems and to strengthen grid infrastructure. However, a widespread blackout in February 2025 exposed vulnerabilities in system resilience and operational co-ordination (Box 1.1).

Box 1.1 ▻ Electricity blackout, February 2025: impacts and call for reforms

On 25 February 2025, Chile experienced its first large-scale blackout since 2010, affecting around 19 million people and causing estimated economic losses of USD 450 million (IEA, 2025). The disruption originated from an unexpected disconnection in a 500 kilovolt (kV) transmission line between the Nueva Maitencillo and Nueva Pan de Azúcar substations, an essential corridor that was transporting power equivalent to 20% of electricity demand at that time. The SEN split into two separate northern and central-southern sub-systems, neither of which were able to remain stable (EPRI, 2025).

The immediate impact underscored the social and political importance of electricity security. Public transportation was disrupted, with the capital's metro system suspended. Critical sectors, including copper mining, were forced to halt operations. In response, the government declared a temporary state of emergency and imposed an overnight curfew. Restoration was delayed due to the loss of a number of communications, monitoring and telecontrol systems. Electricity was restored gradually beginning late on the same day, with about 90% of households reconnected by the early hours of 26 February after the nationwide blackout (Coordinador Eléctrico Nacional, 2025a, b, c).

Chile's unique geography has resulted in a longitudinal transmission system, with major power lines spanning most of the country's length. The facility at the centre of the incident is a critical component of the national grid, enabling electricity flow from solar-rich northern territories to the densely populated central region, where demand is highest. This longitudinal configuration creates operational challenges: power must travel over very long distances, making the system highly sensitive to voltage drops and oscillations. This creates the need for tailored deployment of equipment to help regulate voltage and to keep the system stable.

Twenty days after the event, CEN produced a technical report compiling the chronology of events. To ensure transparency and technical rigour, CEN commissioned an independent review of its report by the EPRI complemented by a study by local researchers to assess the root causes of the event. The EPRI review identified the need to improve grid defence mechanisms and recovery protocols, and recommended measures such as improved protection system redundancy, voltage control for converter-connected generation and enhanced operator training.

1.3 Energy policy developments

The national decarbonisation strategy has benefited from notable continuity in objective setting. A National Climate Change Action Plan was adopted by the Council of Ministers in 2017. Chile's president first announced a national target to achieve net zero emissions by mid-century in 2020, following the country's commitment to fully implement the Paris Agreement taken at the G20 Summit in Osaka a year before. The net zero emissions target was later included in the Long-Term Climate Strategy adopted by the Council of Ministers and communicated to the United Nations Framework Convention on Climate Change (UNFCCC) in 2021, and was eventually enshrined as a legally binding objective in the 2022 Framework Law on Climate Change. The target covers all energy-related sectors.

The Framework Law on Climate Change establishes a national GHG inventory system and introduces economy-wide and sector-level GHG budgets. The land use, land-use change and forestry (LULUCF) sector accounts for more than half of the projected reduction in GHG emissions required to achieve carbon neutrality, underscoring its critical role in balancing residual emissions across the country.

In July 2025, the Council of Ministers adopted an updated Nationally Determined Contribution (NDC). It commits Chile to a 1 100 million tonnes of carbon-dioxide equivalent (Mt CO_2-eq) national emissions budget for the period 2020-2030, with a trajectory implying a peak in GHG emissions by 2025, and sets a 2030 cap for emissions levels of 95 Mt CO_2-eq. It also sets a national emissions budget of 480 Mt CO_2-eq for 2031-2035, with a commitment to limit GHG emissions to 90 Mt CO_2-eq by 2035. It includes sectoral emissions budgets for transport, energy, buildings, and waste and agricultural.

The updated NDC confirms the goal established in 2019 to phase out coal by 2040 through a public-private agreement between the government and the owners of coal assets. It is to be implemented based on a 2020 decree that projected closure of eight coal-fired plants (out of a total of 28) by 2024 as an intermediate step. Since then, 11 coal-fired plants have closed. It also calls for economy-wide energy intensity to decrease by a fifth from 2019 to 2035, and for 80% of power generation to come from renewable sources by 2030. In addition, it reaffirms an objective to reduce domestic methane emissions by 10% by 2035 and for these emissions to peak by 2025. Air quality objectives are included: the NDC requires a 25% decrease in fine particulates from 2016 levels by 2030, and a 30% decrease by 2035, to be implemented through a reduction in black carbon emissions.

The Energy Ministry has regularly produced and updated the corresponding Long-Term Energy Plans (PELP) since 2016. These five-year plans set out energy supply and demand projections over a 30-year horizon under different scenarios. They provide the basis for sectoral policy measures. They include:

- Energy Planning Decree which establishes renewable energy development clusters in specific areas of the country.
- Annual Transmission Expansion Plan.

- Targeted plans such as the Sectoral Plan for Mitigation and Adaptation to Climate Change in Energy, the Green Hydrogen Action Plan 2023-2030, the Mining Sector Climate Change Plan 2025-2029, and the recent Electricity System Decarbonization Plan.

Box 1.2 ▻ Carbon pricing policies in Chile

Chile was one of the first countries in Latin America to design and implement carbon pricing in the energy sector. Its carbon pricing policy landscape is now quite diverse, and includes several carbon pricing instruments.

Chile first implemented a “green tax” in 2017 (Law 20.780). It had three components: a carbon tax, a tax for local pollutants and a tax on new light-duty vehicles. Together these three taxes covered around 40% of the country’s total CO_2 equivalent emissions. The government set the carbon tax at USD 5 per tonne of carbon dioxide (t CO_2) and applied it to all stationary sources with a thermal capacity of 50 megawatts (MW) or more, such as power plants and industrial boilers. The level of the tax for local pollutants, such as sulphur dioxide, nitrogen oxides and fine particulate matter, varied depending on emission levels, population exposure and local pollution conditions. The level of the tax on new light-duty vehicles was based on energy performance and emissions. The green tax initially excluded the transport, steel and mining sectors. A compensation system was also set up, which gave discounts to thermal generators if the amount they had to pay was higher than their marginal costs of operation.

The Tax Modernization Law (Law 21.210), passed in February 2020, introduced two major updates. These lowered the threshold of the carbon tax to include facilities emitting more than 25 000 t CO_2/year, and established a legal basis for a carbon credit compensation system. The changes entered fully into force in 2023 and led to the creation of the Emissions Offset System, which allows entities to compensate for part or all of their taxable emissions by purchasing carbon credits from approved emissions reduction or removal projects within Chile.

In addition, the 2022 Framework Law on Climate Change (Law 21.455) established a system of GHG emission standards and emission reduction certificates. It also recognised the use of Article 6 of the Paris Agreement, which sets a framework for countries to voluntarily co-operate in the implementation of their NDCs through international carbon markets and/or non-market approaches. Its main objective is to enhance global climate ambition while ensuring environmental integrity. Currently, the Ministry of Energy is developing a pilot emissions trading system (ETS) for the energy sector. The pilot ETS is expected to start at the end of 2025 or early in 2026, and it will complement the 2017 carbon tax.

Under its updated NDC and other domestic climate policies, Chile has outlined several measures to strengthen carbon pricing, including:

- A gradual increase of the green tax level to equal the social price of carbon. According to government plans, the tax rate will rise to at least USD 35/t CO_2-eq by 2030.
- A mechanism to incentivise energy efficiency and low-emissions technology uptake in the industry sector. This will take into account the specific circumstances of each industrial sub-sector.
- A rise in the level of current fuel taxes in the transport sector to align with the green tax rate.

Chile is also exploring tapping into international carbon markets to accelerate the decarbonisation of its energy sector. It has signed bilateral agreements with Japan (2015), Switzerland (2024) and Singapore (2025) which may help channel foreign funds to support relevant projects and technologies.

Energy transition by 2050: sector-by-sector analysis

A whole-of-economy strategy for emissions reductions

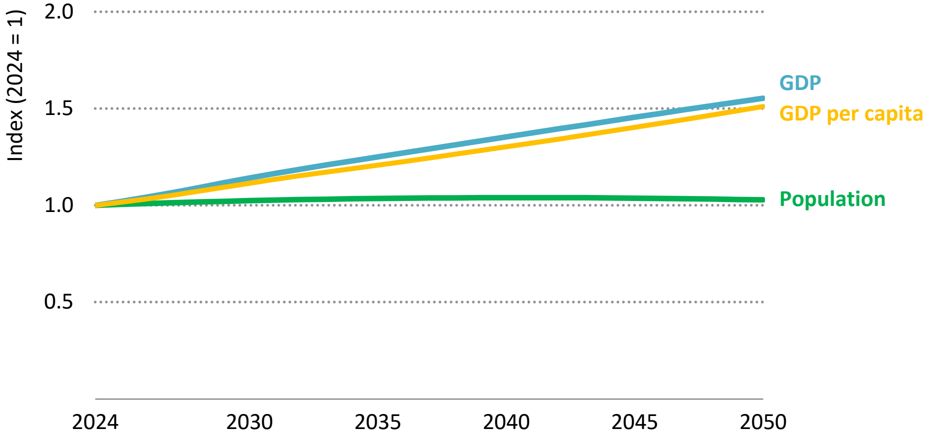
SUMMARY

- Meeting Chile's ambitious climate targets while seeking to improve energy security and enhance long-term economic competitiveness depends on significant changes in its energy sector. The IEA Announced Pledges Scenario (APS) presents a possible pathway. It rests on four pillars: improving energy efficiency; decarbonising the power sector; electrifying end-use sectors; and ensuring that electricity grid modernisation and expansion enable integration of renewables and support electrification.
- Industrial energy demand continues to grow until 2035, after which technical and material efficiencies begin to drive down demand. By 2050, electricity provides half of industrial energy in the APS, up from one-third today. Mining electrifies fastest, seeing widespread replacement of diesel mobile equipment with more efficient battery alternatives that can take advantage of solar resources. Bioenergy and low-emissions hydrogen also make contributions, especially in energy-intensive industry.
- Transport energy demand shifts to electricity as policies like the National Electromobility Strategy drive the sales share of electric vehicles to almost 100% by 2035. Consequently, emissions from transport fall more than 10% even as the number of vehicles increases by almost a third. Aviation and shipping are harder to decarbonise, but liquid biofuels replace almost 20% of Chile's oil demand by 2050.
- Energy demand in the buildings sector is driven down by efficiency gains. In particular, energy demand for space heating more than halves by 2050 as efficient, cost-effective heat pumps become a key supplier of residential heat, and as biomass quality and building insulation improve. Appliance efficiency also contributes, for air conditioning in the north, and as the stock of household devices expands.
- Meeting increasing electricity demands of end-users plus increasing hydrogen production requires power generation to more than double in the next decade. Renewables underpin this growth, making use of its world-class solar resources in the north and wind resources in the south, which supports the continuing phase-out of coal-fired power generation. Dispatchable hydropower and natural gas help support variable renewable integration, battery storage capacity reaches over 8 gigawatts by 2035, and annual grid additions increase fourfold compared to today.
- Chile currently imports over 90% of its fossil fuels. Coal mining ended in 2020, and oil and natural gas production is limited to small fields in the south. In the APS, while fossil fuel production declines, Chile's overall import dependence is reduced thanks to energy transitions.

2.1 Introduction

Our scenarios project continued economic growth in Chile alongside accelerating decarbonisation. The population in 2050 is projected to be 3% larger than in 2024, while gross domestic product (GDP) expands by 2% a year through to 2035 and 1.5% thereafter (Figure 2.1). GDP per capita rose 22% from 2010-2024: it is projected to increase by more than 20% from today's level by 2035, and by more than 50% by 2050.

Figure 2.1 ▹ Key economic and population indicators for Chile, 2024-2050



IEA. CC BY 4.0.

While population remains broadly flat, GDP increases by 55% by 2050

Notes: GDP = gross domestic product. Calculations are based on GDP expressed in year-2024 US dollars at purchasing power parity terms.

Sources: IEA analysis based on IMF, Oxford Economics and United Nations.

2.2 Key pillars of the Announced Pledges Scenario

Chile aims to achieve carbon neutrality by 2050. Its ambitious objective requires comprehensive transformation across its energy system. The Announced Pledges Scenario (APS) pathway is based on four fundamental pillars which collectively aim to reduce greenhouse gas (GHG) emissions while enhancing energy security and economic development (Figure 2.2). None of the pillars stands alone, and there are strong synergies between them: for instance, electrifying end-use demand (as part of pillar 3) improves energy efficiency (pillar 1), and enables low-emissions electricity to displace direct fuel use (pillar 2), but ultimately depends on resilient and secure electricity grids (pillar 4).

Pillar 1: Energy efficiency – towards a cost-effective transition

Energy efficiency serves as the cornerstone of the APS pathway, which sees final energy intensity decline from 2024 levels by 20% by 2035 and around 45% by 2050. The economic rationale is compelling: improving energy efficiency reduces spending on fuel and dependence on fuel imports, while concurrently it lessens the need for new near-zero emissions technologies, particularly in hard-to-abate sectors, and for capacity additions of renewable sources.

Pillar 2: Decarbonisation of the power sector – the cornerstone

In the APS, the power sector sees carbon dioxide (CO_2) intensity drop to 15% of current levels by 2035 and almost 5% by 2050. This rapid reduction in CO_2 intensity is driven by the accelerated phase-out of fossil fuel power generation, rapid expansion of renewables, and strategic reinforcement of grid infrastructure to integrate variable renewables and to ensure reliable power delivery. The decarbonisation of the power sector is critically important as all end-use sectors rely on electrification as the primary means of emissions reduction. Fortunately, Chile has excellent renewable energy resource potential to provide a foundation in pursuit of this goal.

Pillar 3: Electrification and switching to low-emissions fuels in end-uses – tackling the demand side

The third pillar is widespread electrification and fuel switching in end-use sectors which reshapes energy consumption patterns in Chile. The share of electricity in total final consumption increases from 23% today to approximately 30% by 2035 and 55% by 2050 in the APS. This electrification path is complemented by strategic hydrogen development and deployment, with low-emissions hydrogen [1] accounting for about 5% of total final consumption in 2050, notably for end-uses that are difficult to electrify directly such as energy-intensive industry, long-distance transport and heavy-duty mobile equipment used at mining operations. The comprehensive fuel switching strategy in the APS requires significant investment in new infrastructure, but provides an opportunity to improve energy security, energy efficiency and economic competitiveness.

Pillar 4: Reliable and resilient electricity grids – the backbone of electrification and renewables integration

Ensuring robust and resilient electricity grids is the fourth transition pillar. It underpins the electrification of end-uses and supports the transition to a decarbonised electricity sector. Grids are a crucial element of the energy transition in Chile. The APS sees an expansion of around 40% from 2024 to 2035 and rising to around 240% by 2050, driven largely by higher

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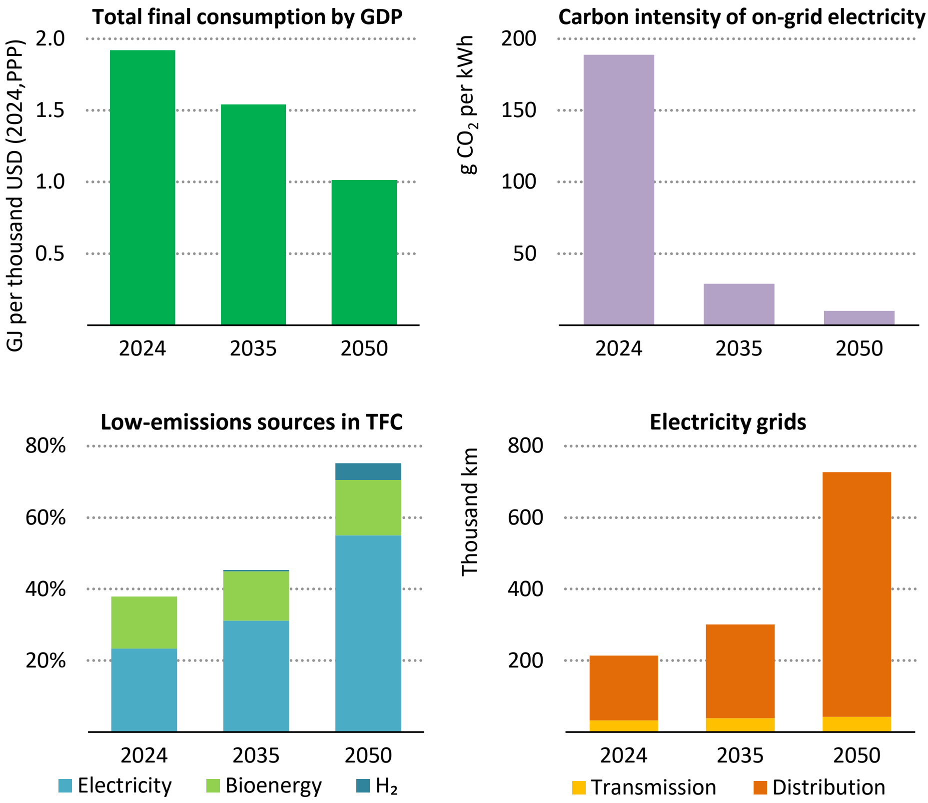
[1] Low-emissions hydrogen refers to hydrogen produced through water electrolysis with electricity generated from low-emissions sources, such as renewables. It also includes hydrogen produced from biomass, or from fossil fuels with carbon capture, utilisation and storage, provided that high CO_2 capture rates are achieved. Please refer to Annex C for more details.

investment in distribution networks. Grid expansion will enable Chile to make the fullest possible use of its abundant solar and wind resources, which are concentrated far from major demand centres. Investment will also be needed in digitalisation, grid automation and advanced transmission technologies to ensure system stability. Ultimately, affordable electricity hinges on the successful integration of renewables into a modernised grid.

Figure 2.2 ▷ Key pillars of energy transition pathway in Chile in the APS, 2024-2050



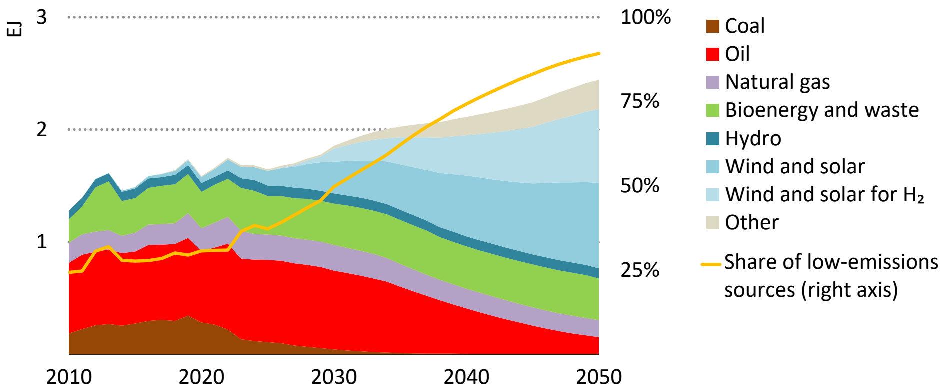
Chile's energy transition depends on four pillars: improving efficiency, decarbonising the power sector, electrifying end-use sectors and resilient electricity grids

Note: TFC = total final consumption; GJ = gigajoule; PPP = purchasing power parity; g CO_2 = grammes of carbon dioxide; kWh = kilowatt-hour; km = kilometre; H_2 = hydrogen and hydrogen-based fuels.

2.3 Energy demand

Total energy demand in Chile faces contrasting dynamics in the APS. Economic growth spurs increasing demand, but efficiency improvements, often driven by electrification, work to moderate fuel consumption. Despite efficiency gains, energy demand in Chile increases 20% by 2035 compared to 2024 levels, and around 45% by 2050 (Figure 2.3). This growth is driven by the development and deployment of low-emissions hydrogen production, which accounts for 85% of the increase in energy demand by 2050. This enables Chile to make use of low-emissions hydrogen in the domestic market, while also creating export opportunities and positioning the country as a prominent player in the global low-emissions hydrogen market (see Chapter 4).

Figure 2.3 ▹ Energy demand by source and share of low-emissions sources in Chile in the APS, 2010-2050



IEA. CC BY 4.0.

Low-emissions sources in energy demand rise from a 38% share in 2024 to more than 60% in 2035 and 90% by 2050 – a significant transformation

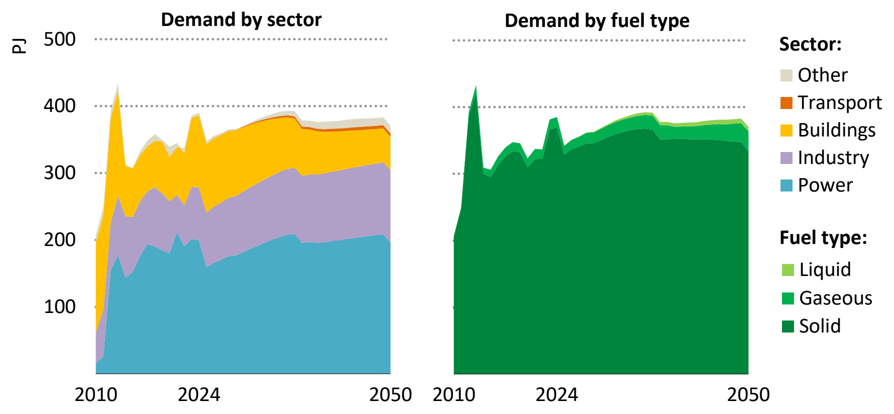
Notes: EJ = exajoule. Wind and solar for H_2 refers to the use of wind and solar energy for low-emissions hydrogen production for both domestic use and export.

The share of low-emissions sources in energy demand rises from 38% in 2024 to more than 60% by 2035 and 90% by 2050. Wind and solar capacity expansion drives this clean energy transition, with the output of these technologies increasing by a factor of more than five by 2035 and by a factor of 12 by 2050 relative to today. Hydropower continues to play an important role, meeting 5% of demand in 2035 and 4% in 2050. Bioenergy use remains largely unchanged in absolute terms, though its share declines from nearly 25% today to 15% by 2050 (Box 2.1).

Box 2.1 ▻ Bioenergy – here to stay

Bioenergy accounts for about 23% of energy demand – the second most commonly used fuel in Chile. In 2024, consumption reached nearly 400 petajoules (PJ), almost entirely in the form of solid biomass. About half was used in the power sector, with the remainder split between industry and space heating in buildings, particularly in southern regions where many households continue to use wood as a fuel (Figure 2.4).

Figure 2.4 ▻ **Bioenergy demand by sector and fuel type in Chile in the APS, 2010-2050**



IEA. CC BY 4.0.

Bioenergy use remains broadly stable to 2050, with slow growth in industry partially offsetting a steady decline in the buildings sector

Note: PJ = petajoule.

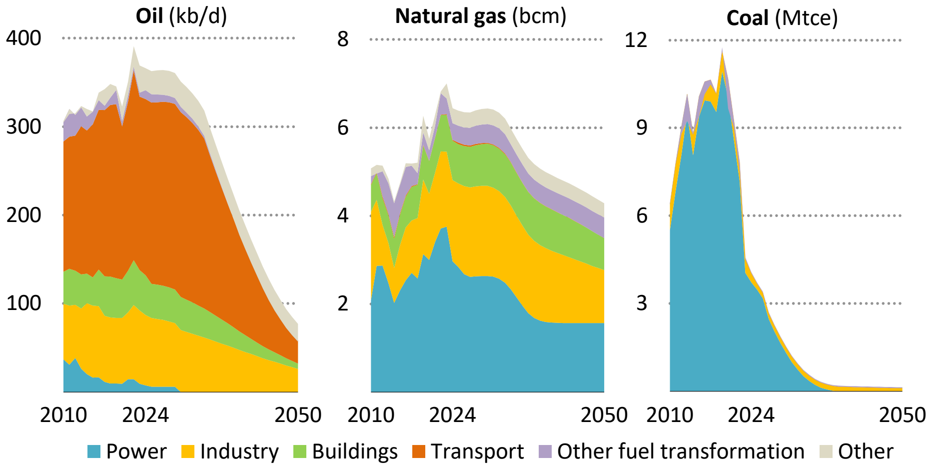
In Chile, the Long-Term Energy Planning (PELP) and Just Energy Transition Strategy prioritise the expansion of wind and solar photovoltaics (PV), while recognising the importance of bioenergy as a complementary source for dispatchable power and hard-to-abate sectors. Scaling up bioenergy faces challenges, including high investment costs, limited biomass availability, constrained infrastructure for biogas upgrading, and strong competition from low-cost solar and wind. However, organic waste streams could supply up to 78 PJ per year of sustainable bioenergy, mainly from livestock manure and crop residues, if regulatory and financial barriers are addressed (Ludlow, et al., 2021).

In the APS, total bioenergy use remains broadly flat to 2050, although its share declines from 23% today to about 15% by 2050. Solid biomass continues to dominate, although biogas and to a lesser extent liquid biofuels gain ground by 2050. In buildings, bioenergy consumption declines by more than 50% by 2050 compared to today as the number of households using biomass drops by a quarter and households use more efficient stoves and more efficient fuel, e.g. pellets and low moisture firewood. This decline is partially offset by increased use in the industrial sector.

The share of fossil fuels in the energy mix in the APS falls from around 65% today to about 40% by 2035 and just 12% by 2050. Each fossil fuel follows a distinct trajectory (Figure 2.5).

Oil demand decreases in the APS from over 350 thousand barrels per day (kb/d) in 2024 to about 300 kb/d by 2035 and roughly 75 kb/d by 2050. Oil is currently the most important fuel in Chile, and it accounts for more than 70% of fossil fuel demand in 2035. However, demand for oil decreases faster than demand for natural gas beyond 2035, and natural gas accounts for the same share of fossil fuel consumption as oil by 2050. The reduction in oil use is largely attributable to increased uptake of electric vehicles (EVs) in the transport sector, supported by efficiency targets, expanded charging infrastructure and more affordable EV models. Oil use in other sectors – including in the mining sub-sector and for heat in buildings – also declines steadily as low-emissions alternatives scale up.

Figure 2.5 ▷ Oil, natural gas and coal demand by sector in Chile in the APS, 2010-2050



IEA. CC BY 4.0.

Oil and coal demand decline sharply, while natural gas demand falls by a third to 2050

Note: kb/d = thousand barrels per day; bcm = billion cubic metres; Mtce = million tonne of coal equivalent.

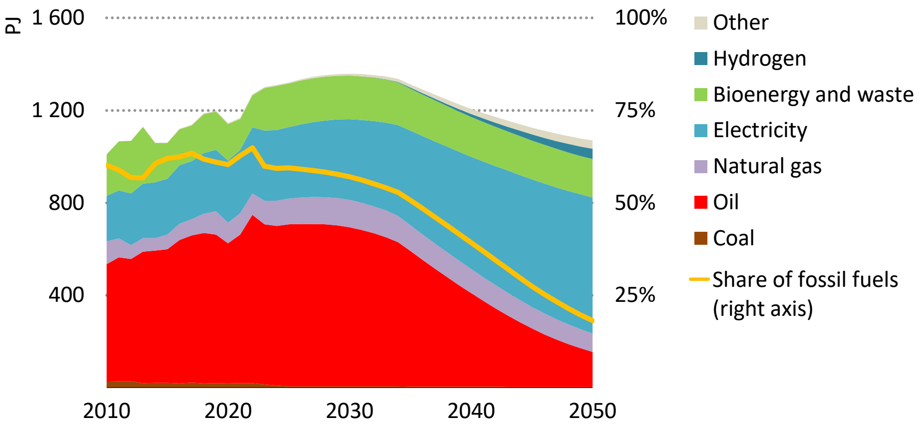
Natural gas demand, which stood at over 6 billion cubic metres (bcm) in 2024, falls under 6 bcm by 2035 and to 4 bcm by 2050 in the APS, primarily due to its shrinking role in power generation. As solar and wind generation expands, natural gas-fired power plants pivot from producing bulk electricity to supplying flexibility and secure capacity. Outside the power sector, primarily in industry, notably as a feedstock for methanol production, and in buildings for heating, natural gas use decreases at a lower rate through to 2050.

Coal demand in Chile has already fallen sharply from a peak of nearly 12 million tonnes of coal equivalent (Mtce) in 2019 to about 4 Mtce in 2024. This decline is set to continue, driven by the phased retirement of coal-fired power plants due to be completed by 2040. Residual coal demand, projected to just over 0.1 Mtce in 2050, is confined mainly to industrial uses.

2.4 End-use sectors

Total final consumption in Chile follows a different trajectory than total energy demand, remaining relatively flat through to 2035 and then declining by 20% from today's level by 2050 (Figure 2.6). The ability to meet rising energy services demands while decreasing energy consumption in the APS is the result of accelerated efforts to electrify end-uses and improve energy efficiency. Electric technologies are much more efficient than the technologies they displace: for example, electric cars are two-to-four-times more efficient than fossil fuel alternatives, and heat pumps are around three-to-five-times more efficient. Technical energy efficiency gains are also important. The 2021 Energy Efficiency Law (Law No. 21.305) establishes rigorous standards and incentives across all end-use sectors, specifically identifying the scale of the opportunity in mining operations and residential heating. In the APS, measures across all sectors bring about an annual improvement in final energy intensity of 2% through to 2035, and 2.8% in the period 2035 to 2050.

Figure 2.6 ▹ **Total final consumption by source and share of fossil fuel sources in Chile in the APS, 2010-2050**



IEA. CC BY 4.0.

Total final consumption declines after 2030, with efficiency gains from electrification and energy efficiency policies enabling the delivery of more services with less energy

The share of fossil fuels in end-use sectors undergoes a substantial transformation, declining from 62% in 2024 to 54% in 2035 and reaching 22% by 2050. Electricity drives much of this transition, with its share in total final consumption increasing from 23% in 2024 to over 30% in 2035 and 55% by 2050. The share of bioenergy and waste remains steady at around

14-16%, but this delivers significantly more useful energy than today as fuel quality improves and efficiency gains in heating and cooking technologies reduce energy waste, and it increases its share in the industry sector. Similarly, natural gas maintains its share at approximately 8%, and is mostly used in industry, particularly as a feedstock for methanol production. Low-emissions hydrogen starts to make inroads after 2035, and, including onsite production, is equivalent to 5% of total final consumption in 2050: it is used primarily to power heavy mobile equipment in mines, heavy freight trucking, chemicals production and other activities which are difficult or impossible to electrify.

2.4.1 Industry sector

Industrial energy demand in Chile is set to grow slightly at a rate of around 0.4% each year over the next decade. Despite this growth, emissions continue to fall from their 2022 peak at an average rate of 2.4% each year in the APS.[2] Beyond 2035, total industrial energy demand begins to fall, driven by faster improvements in material and technical efficiency, and this brings further reductions in emissions. In the APS, industrial energy efficiency – measured as the ratio of energy demand to value added by industry – improves by 1.5% per year on average to 2035, and 1.7% on average afterwards until 2050. This is a big increase compared to the slight decline seen on average over the last decade and reflects a combination of technical improvements to existing processes, electrification and improved material efficiency.

Oil import dependence declines as the share of oil in industrial energy demand drops from almost one-third today to one-tenth in 2050 (Figure 2.7). Natural gas use in industry declines by 35% by 2050 compared to today, with methanol production accounting for 85% of natural gas use in industry by 2050, up from 60% today. Although electrolytic hydrogen accounts for about a quarter of hydrogen feedstock produced for methanol production by 2050, natural gas also continues to play a role as a source of CO_2 feedstock.

By contrast, the share of electricity in industrial energy demand grows six percentage points by 2035 in the APS, by which time it meets 43% of industrial energy demand. This growth is concentrated in the mining sub-sector, although there is a small contribution from some electrification of methanol production. The share of bioenergy in industrial energy demand also increases, rising from 16% in 2024 to 22% in 2050 mostly as a result of its rising use in energy-intensive industries, where it provides 73% of energy in the pulp and paper sub-sector by 2050, and 31% in the cement sub-sector, up from 63% and 10% in 2024 respectively.

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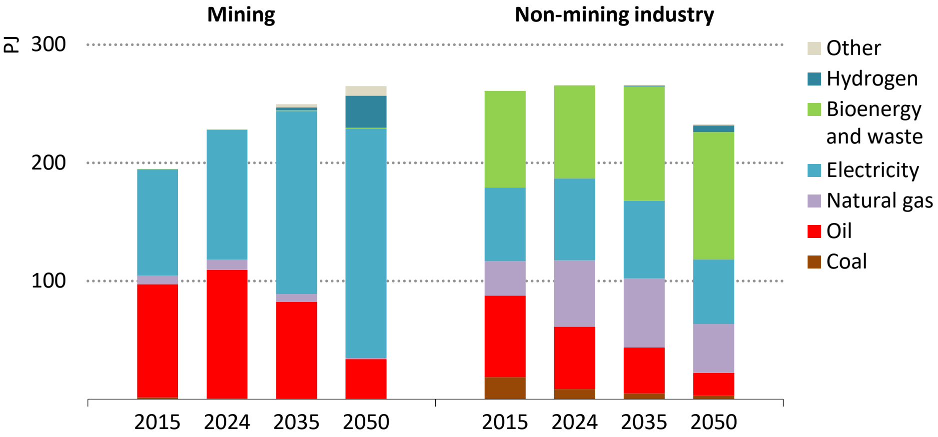
[2] Industrial emissions include both emissions from combustion of fossil fuels and emissions from industrial processes which chemically or physically transform materials, e.g. the release of CO_2 from the production of cement from calcium carbonate.

Figure 2.7 ▻ **Energy demand by fuel in mining and non-mining industries in Chile in the APS, 2015-2050**



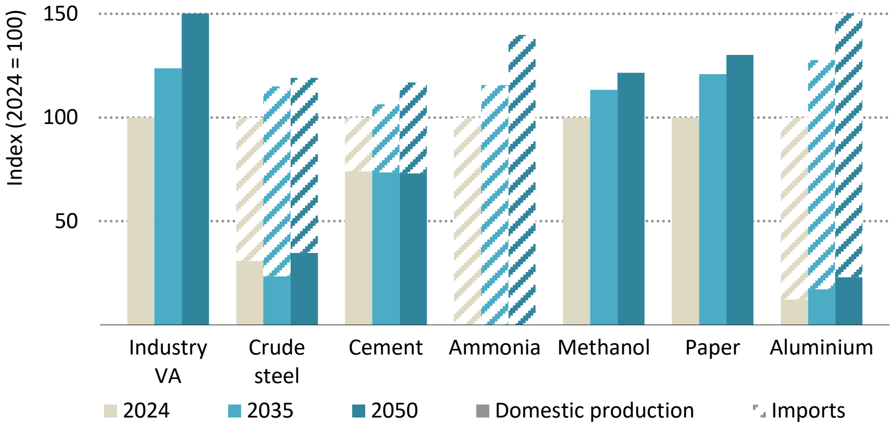
IEA. CC BY 4.0.

Mining uses around half of industrial energy and is a good candidate for further electrification, while non-mining industry improves efficiency and use more bioenergy

Material efficiency is responsible for a third of the emissions reductions from energy-intensive industries between now and 2035. Steel production in Chile already employs only recycled materials. The cement, aluminium and chemicals sub-sectors reduce raw material demand in the APS by increasing the use of substitute cementitious materials and by expanding scrap and plastics recycling. More efficient end-use, like longer building lifetimes also reduces overall material demand to reduce the demand for steel, cement and methanol by between 3 and 9% respectively by 2035, compared to a case without efforts to improve material efficiency. Overall, these reductions in end-use material demand cut energy demand by 7% in energy-intensive industry by 2050 compared to today. Material efficiency is a cost-effective option for emissions reduction in the industry sector, and reduces the need for new technologies in hard-to-abate sectors, some of which require high levels of investment.

Products from heavy industry are the foundational materials for many other sectors, and demand for them continues to grow in the APS (Figure 2.8). Chile is dependent on imports of many key industrial products, including ammonia, which is mostly used for explosives for the mining industry, and also indirectly imported in the form of nitrogenous fertilisers. (Chapter 4 discusses how the emergence of a low-cost hydrogen industry in Chile could alter this domestic demand outlook by onshoring production of some key industrial materials, particularly ammonia.)

Figure 2.8 ▹ **Key industrial products: demand, domestic production and imports in Chile in the APS, 2024-2050**



IEA. CC BY 4.0.

Chile is heavily dependent on imports of key industrial products, except for methanol and paper

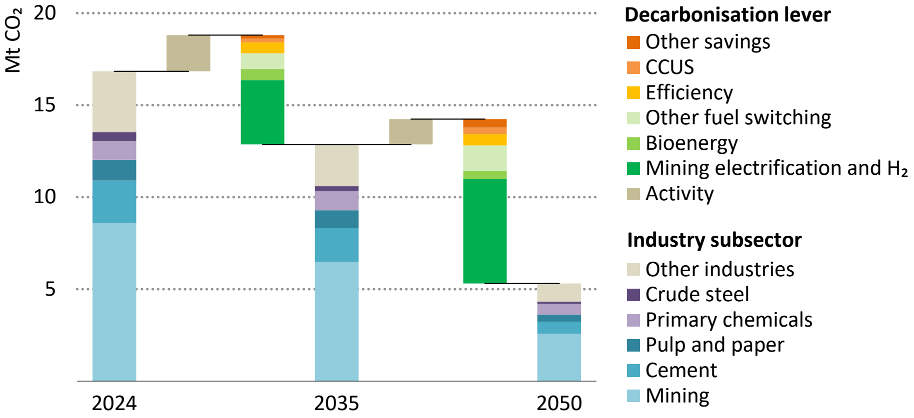
Notes: VA = value added. Ammonia refers only to ammonia produced for conventional uses, which in Chile is mainly for fertiliser and as explosives in mining, and not for use as a fuel. (Export projects and the use of ammonia as a hydrogen-based fuel are discussed in Chapter 4.)

Emissions trajectory

In the APS, CO_2 emissions in the industry sector fall from today's level by 24% in 2035 and 68% in 2050 (Figure 2.9). The majority of the reductions to 2035 stem from fuel switching, with electrification of mining and other light industries such as manufacturing and textiles playing an especially important role. Beyond 2035, achieving higher emissions reductions in some sub-sectors requires new technologies which have not yet been deployed at scale. With its rich renewable energy resources, Chile is well placed to produce hydrogen by electrolysis. In the APS, hydrogen meets 7% of industrial energy demand by 2050, mostly in the mining industry. On-site electrolysis produces 25% of the hydrogen used for local methanol production by 2050.

Achieving deep decarbonisation in heavy industry requires deployment of carbon capture, utilisation and storage (CCUS) technologies. The APS sees 1.1 million tonnes (Mt) of CO_2 stored per year in the industry sector by 2050, equivalent to about 6% of its current industrial emissions. More than 90% of this is required to decarbonise the non-metallic minerals sub-sector, in particular for cement production. Although CCUS increases production costs, the difficulty of decarbonising cement production means that it is hard to achieve net zero emissions without some use of CCUS technologies.

Figure 2.9 ▻ **Key decarbonisation levers for emissions reduction in industry in Chile in the APS, 2024-2050**



IEA. CC BY 4.0.

Fuel switching is the most important driver of emissions reductions, but efficiency measures and new technologies like CCUS are also needed to achieve deep decarbonisation

Notes: Mt CO_2 = million tonnes of carbon dioxide; CCUS = carbon capture, utilisation and storage. Efficiency includes material and technical efficiency improvements. Other savings include deployment of geothermal and concentrating solar thermal, and a slight decline in the CO_2 intensity of fossil fuels.

Electrification is the key lever for decarbonisation of mining

Mining – mostly copper, but also lithium, molybdenum and a number of other minerals – is critical to the economy and energy sector in Chile. Mining accounts for almost half of industrial energy consumption. Growth in its energy demand growth continues in the APS until 2050, despite ongoing technical efficiency improvements, driven by increasing demand for minerals and metals as well as declining ore grades (see Chapter 4, section 4.3). Mining-related emissions reductions are supported by the Mining Sector Climate Change Plan, which sets clear emissions budgets for each decade going forward. The mining sub-sector in Chile already sources around half of its energy from electricity, which it uses mostly for crushing and grinding of mineral ores, copper concentration and electro-winning. The APS sees further deployment of electrification in mining operations, and the electricity share of the energy used in mining rises over 60% by 2035.[3]

Oili is the main fossil fuel in the industry in Chile. It is used mostly used for haulage trucks and mobile equipment like excavators. The National Electromobility Strategy, which applies to mining trucks, requires that all large mobile machinery sold by 2035 be zero emissions.

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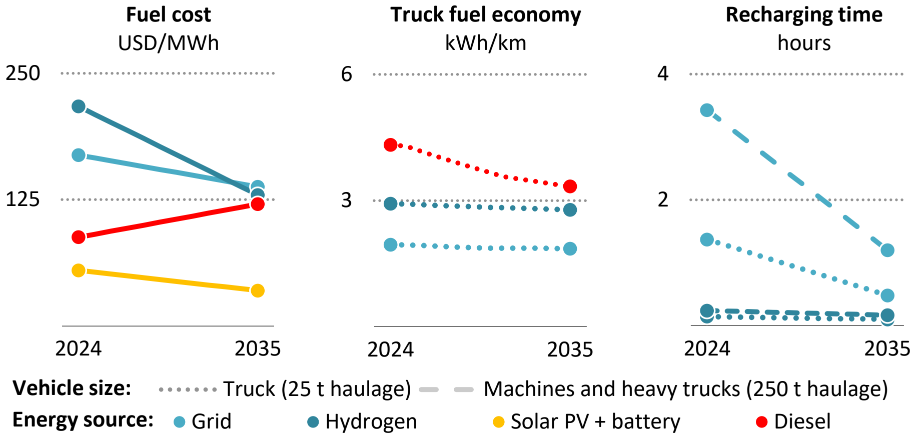
[3] Some mining operations use electricity for desalination due to limited freshwater availability in northern Chile where many ore deposits are located. The energy demand associated with desalination is not within the scope of the industry sector energy use classification, but those energy demands are discussed in Box 2.3.

This is set to lead to the electrification of vehicles used in mining, and is the primary driver for electricity demand in mining being projected to increase by 12 terawatt-hours (TWh) by 2035, equivalent to 4% of total electricity consumption today in Chile. A number of large electrification projects show that this change is already under way. For example, the Escondida mine – the world's top producing copper mine – has already started to replace its fleet of 160 trucks with electric alternatives, and aims to complete electrification by 2033. Additional policy measures, such as support for off-grid renewables or grid strengthening in the Antofagasta region, where many copper mines are located, could further accelerate the electrification trend and reduce dependence on imported oil.

Figure 2.10 ▻ Fuel costs and technical parameters of mining equipment by fuel type in Chile in the APS, 2024-2035



Electricity can be both a low-cost and high efficiency fuel for use in mining trucks, depending on the source, but hydrogen vehicles can be refuelled much more quickly

Notes: USD = US dollar; MWh = megawatt-hour; t = tonne. Grid prices are based on the annual average. Hydrogen fuel costs assume off-grid production in the Antofagasta region and include estimates of the hydrogen storage cost. Refuelling infrastructure costs are not included in the fuel cost for any fuel. Truck batteries are estimated at 0.8 MWh and heavy machinery batteries at 2 MWh. Electric recharging time assumes the battery is recharged from 20% to 80%; hydrogen recharging time delivers an equivalent range to the electric option. 350 kilowatt chargers are used in 2024, and 1 megawatt chargers are used in 2035.

The business case for electrification of mining trucks is steadily improving. Mining trucks are bespoke vehicles which can cost over ten-times more than heavy freight trucks used in on-road applications, depending on the size of the vehicle. Although electric alternatives have higher upfront costs, rapid acceleration in battery technology is driving costs down. Because they are two to three-times more efficient than their diesel alternatives, today electric trucks are around 15% cheaper to operate when charged using grid electricity (Figure 2.10). Since mining trucks are operated on an almost 24-hour schedule, fuel costs are a significant contributor to the total cost of operation. In many instances, lower fuel costs translate into a lower total cost of ownership. Fuel costs could be lowered even further by exploiting the low-cost solar power potential in the Antofagasta region where the copper industry is concentrated, which would also reduce security risks associated with imported fuels or electricity grids (Box 2.4). Continuous operation of electric mining trucks places significant stress on their batteries, underscoring the importance of adopting battery designs that maximise lifetime, as well as implementing appropriate operating and charging protocols to reduce degradation and the need to replace batteries.

New infrastructure is needed to enable electrification and support high-speed charging. It is a prerequisite to minimise mobile equipment downtime, though the chargers and their associated grid upgrades may carry high prices. If mines do not connect to the electricity grid, they face high costs for batteries that can enable 24-hour operation. Electrifying a fleet of 100 large haul trucks, each with a battery capacity of 2 megawatt-hours (MWh), implies an average power demand of about 15 megawatts (MW), which is small relative to some other industries such as a conventional data centre that draws around 25 MW or a 100 kilotonne per year primary aluminium smelter consumes at about 200 MW. However, peak power demand could be much higher for mining, e.g. if all charging occurred during shift changes, peak power demand could exceed 100 MW. Mine shift patterns, vehicle movements and charging schedules need to be carefully managed to help reduce the cost of new electrified systems, taking advantage where possible of periods of low electricity prices. Emerging technologies and innovative practices also have a part to play. For example, dynamic charging infrastructure using pantograph technology can enable vehicles to recharge while they are in use, and battery swapping technology is being tested at copper mines in Mongolia to reduce recharging times and peak electricity demand.

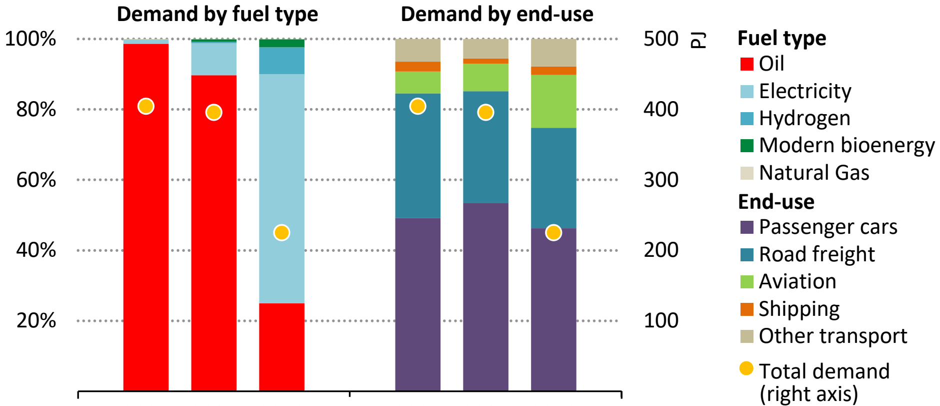
Electricity offers higher efficiency and lower total energy costs than both diesel and hydrogen fuels used for mobile equipment, but it is challenging to electrify some applications. For instance, the electric bucket excavators at Centinela, a large copper and gold mine in the Atacama region, can only be used for four hours after having been charged for three hours, whereas its small trucks can work for seven hours after a single hour of charging. Large prototype hydrogen haulage trucks with payloads more than 150 tonnes have been used at mines in Australia, the People's Republic of China (hereinafter China) and South Africa to indirectly electrify haulage and reduce refuelling times. Some of the usual challenges of deploying hydrogen in the road transport sector, such as building adequate charging infrastructure, or finding land for hydrogen storage tanks, are more manageable in off-road transport for mining because equipment has predictable, scheduled movements and does not travel long distances.

Although accelerated recharging is a significant benefit, there are a number of barriers to hydrogen deployment for mining mobile equipment. Hydrogen refuelling infrastructure is expensive, and can represent more than a third of the delivered costs of fuel (IEA, 2025). It can also be challenging to source the water needed for local production of hydrogen in the arid regions where the mines are located in Chile. Furthermore, the advantages of accelerated refuelling times for hydrogen may decline over time if ambitions for megawatt-scale charging of electric equipment come to fruition. The overall efficiency and operating cost advantages of electrification are likely to make it the preferred option for most mobile equipment, and that is reflected in the APS. However, for sites with large amounts of heavy equipment, or where the expansion of the electricity network constrains the capacity to add reliable high-speed charging for all equipment, hydrogen may well prove to be an effective replacement for oil.

2.4.2 Transport sector

Road transport accounted for around 90% of the more than 400 PJ of annual demand for energy in the transport sector in 2024 (Figure 2.11). Aviation accounted for 6% and shipping for 3%. In the APS, the electrification of passenger cars and light commercial vehicles brings significant efficiency improvements, as do fuel economy standards that incentivise further technical efficiency improvements in internal combustion engine (ICE) vehicles and support the penetration of EVs over time. Electric bus sales continue to increase in the APS, and electric medium- and heavy- freight truck sales start to rise especially beyond 2030. As a result, energy demand across the transport sector is around 3% lower than today in 2035, and 45% lower in 2050. Meanwhile energy demand for aviation rises and its share of total transport energy demand increases reaching 8% by 2035; up from 6% today.

Figure 2.11 ▷ Share of energy demand and total energy demand for transport by fuel and mode in Chile in the APS, 2024-2050



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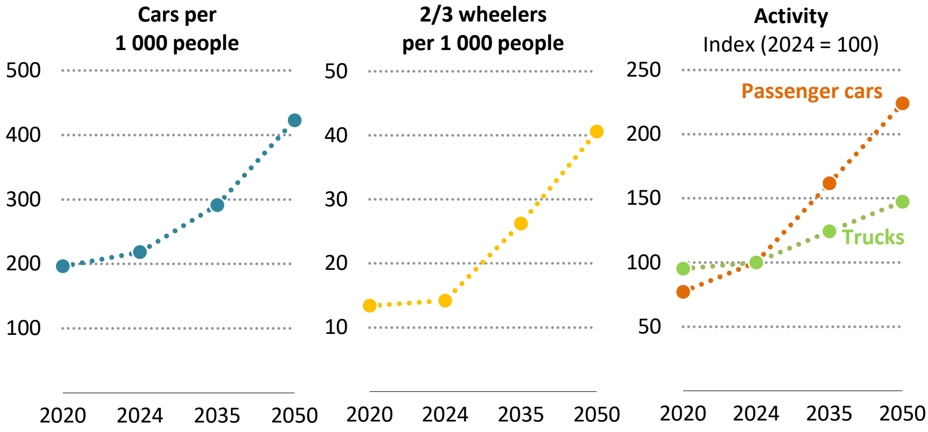
Electrification and the uptake of hydrogen-based energy carriers decrease total oil demand in transport

Notes: Other transport includes two/three-wheelers, buses, rail, non-specified transport and energy consumed in the delivery of fuels through pipelines.

The share of oil in transport energy consumption falls from almost 100% today to 90% in 2035 and around 25% in 2050, while the share of electricity accelerates from 1% in 2024 to nearly 10% by 2035 and 65% in 2050. Aviation and shipping are difficult to electrify, but there is scope to reduce emissions by making use of hydrogen-based energy carriers, which account for around 8% of total transport energy demand by 2050 in the APS. Bioenergy is also increasingly used alongside hydrogen-based fuels in the aviation sector.

Figure 2.12 ▷ Vehicle ownership and road transport activity in Chile in the APS, 2020-2050



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Car ownership doubles by 2050 and passenger transport activity more than doubles, while road freight activity increases by 60%

Notes: Index of activity based on passenger-kilometres for passenger cars and tonne-kilometres for trucks. Trucks includes heavy and medium freight trucks used on-road (off-road trucks such as those used in mining are treated separately in the industry sector).

Car ownership is rising in Chile as incomes increase, nearly doubling by 2050 (Figure 2.12). Economic growth drives road freight activity to 60% above the current level by 2050.[4] Chile has no domestic car manufacturing and therefore imports all its cars. In 2016, Korea, Europe and Japan were the top-three exporters of cars to Chile. Yet since 2018, China has lead imports, increasing the number of cars imported nearly fivefold from 2016 to 2022 (Figure 2.13). In 2024, China accounted for over two-out-of-five cars sold in Chile, well ahead of India at 13% and Japan at 11% of car imports in Chile. EVs accounted for 4% of car imports in 2024, of which over 70% were from China.[5]

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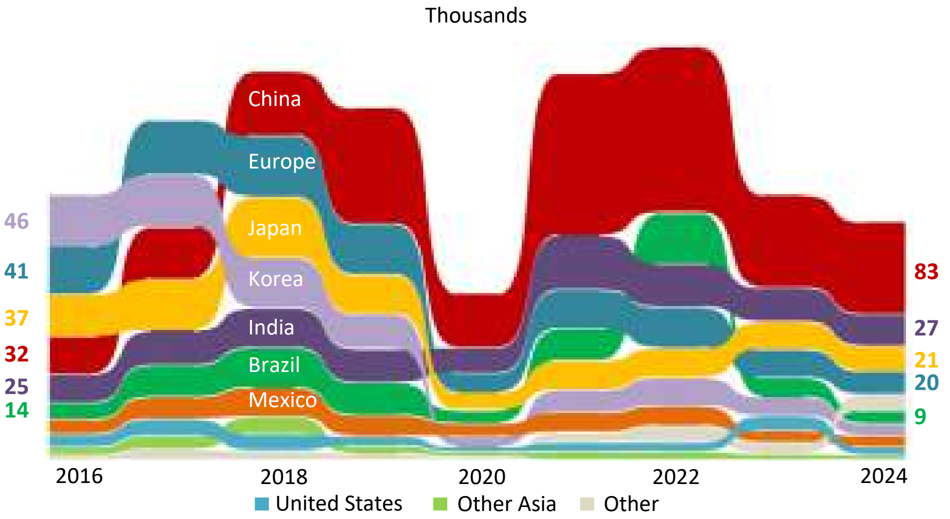
[4] Off-road vehicles used in mining are classified under the industry sector, not as part of the transport sector (see section 2.4.13.-809247808).

[5] EVs include battery electric vehicles and plug-in hybrid electric vehicles.

Chile has clear policies in place to ensure the quality of imported vehicles. It prohibits the import of used vehicle that are more than five-years old, although there are some exceptions, notably for free trade zones. Light-duty and medium-duty vehicles must meet Euro 6c emissions standards. Heavy-duty vehicle imports must meet Euro 5 standards, and Euro 6 standards will apply from 2026.

Figure 2.13 ▻ Cars imported to Chile by country of origin, 2016-2024



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In recent years, China became the largest exporter of cars to Chile, accounting for more than 40% of imports in 2024

Electrification, the key pillar for road transport decarbonisation

In 2021, Chile enacted a law setting fuel economy targets for light-duty vehicles which entered into force in 2024. It supports the deployment of EVs by allowing for triple counting of zero emissions vehicles in the average fuel economy calculation for fleet sales.[6] There are, in addition, several other incentives for consumers to switch to lower emissions vehicles. For example, the emissions-based road tax system that exempted zero emissions vehicles from road tax in 2023 and 2024, and provides preferential tax rates until 2030.

In the APS, the market share of electric cars in Chile increases from around 2% in 2024 to nearly 100% in 2035, in line with the National Electromobility Strategy. This rapid shift depends on several enabling conditions, including adequate provision of charging stations in

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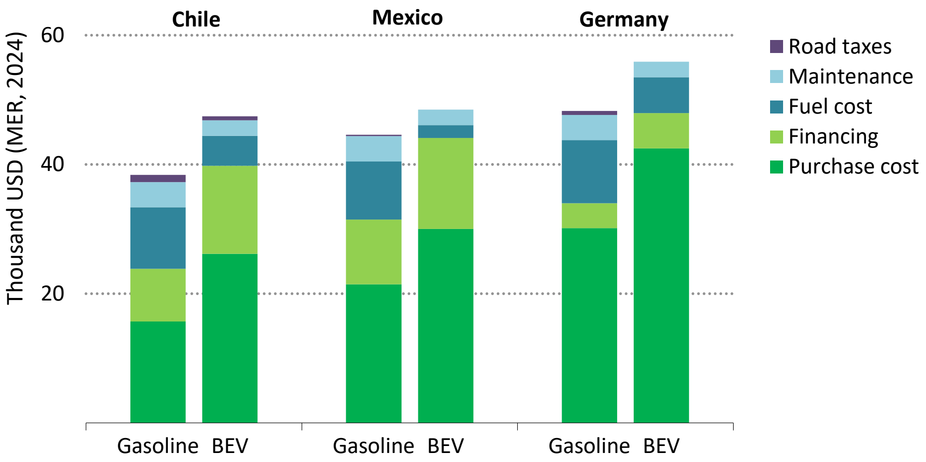
[6] The current penalty mechanism for missed targets is a fine of approximately USD 80 for each 1 km per litre of gasoline equivalent of shortfall per vehicle sold by the manufacturer.

both urban and rural areas, supportive tax and fuel efficiency policies and regulations, and access to affordable EV models for consumers.

Progress is already being made. During the first three-quarters of 2025, electric car sales in Chile accelerated, reaching a market share of nearly 3%, compared with 2% in 2024. By late September 2025, there were over 1 500 publicly accessible charging points, and this number is projected to increase over 40-fold for light-duty vehicles by 2035 in the APS. However, the upfront costs of buying an EV and associated financing costs are still higher than for an ICE vehicle (Figure 2.14), and only three EV models on the market in Chile are currently priced around or below USD 20 000. EVs could be made more attractive to potential buyers through tax incentives, battery leasing programmes and lower interest rates for buyers.

Figure 2.14 ▹ Total cost of ownership over five years of gasoline versus battery electric compact SUV in Chile, Mexico and Germany



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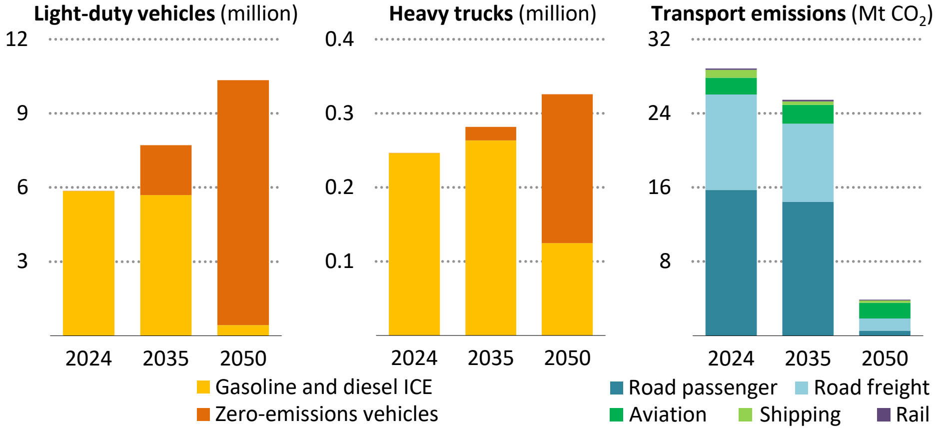
Further reductions in purchasing and finances costs for EVs would improve their competitiveness relative to gasoline equivalents

Notes: SUV = sport utility vehicle; MER = market exchange rate; BEV = battery electric vehicle. Comparison based on compact SUV segment across the three countries, financing assumes a deposit of 30% on the purchase price, with interest rates of 14% for Chile; 13% for Mexico and 6% for Germany. The analysis considers a five-year ownership period, with road and circulation taxes calculated from a 2026 purchase year. Fuel economy range for gasoline engines is 7-8 litres per 100 km, while BEV models consume 0.19 kWh/km.

As electromobility infrastructure for road transport expands, and EV sales continue to accelerate, the stock of zero emissions passenger light-duty vehicles increases from under 8 000 in 2024 to nearly 2 million in 2035 and to over 8 million by 2050 in the APS (Figure 2.15). For heavy-duty vehicles, Chile has issued its national roadmap stating that 100% of heavy vehicle sales will be zero emissions by 2045. In the APS, this drives an increase in zero emissions road medium- and heavy-freight trucks from less than 0.1% of the market in 2024 to 20% in 2035, and the stock of zero emissions medium- and heavy-freight trucks expand from about 300 today to more than 18 000 in 2053, and just over 200 000 by 2050. Chile is also pursuing an ambitious bus electrification strategy (see Chapter 1). In the APS, electric vehicles account for the majority, reaching 98% of zero emissions vehicles in Chile by 2050: the remaining vehicles make use of hydrogen fuel cells, which are a cost-effective option for some long-distance applications, and in clusters in transport hubs along routes of high activity and in refuelling ports, making use of the potential for hydrogen production in Chile.

Figure 2.15 ▷ Stock of vehicles by fuel type, and emissions by transport mode in Chile in the APS, 2024-2050



IEA. CC BY 4.0.

As the stock of zero emissions vehicles expands, transport-related CO_2 emissions falls nearly 90% by 2050, with aviation making up around 45% of remaining emissions

Note: Light duty vehicles include road passenger light duty vehicles and road light-commercial vehicles. Heavy trucks includes heavy and medium freight trucks used on-road (off-road trucks such as those used in mining are treated separately in the industry sector).

An increasing stock of EVs means a need for adequate vehicle charging. Chile has issued new regulations to support EV charging, including the 2022 regulations on Interoperability of Electric Vehicle Charging Systems by Decree No. 12. These charging regulations include an open protocol which supports interoperability across networks and real-time information for customers. Meanwhile, the number of public charging points is rapidly increasing, although around 75% of them are located in the metropolitan area around Santiago (Observatorio Infraestructura de Carga en Chile, 2025). Chile has about 1 500 public charging points, which equates to about one public charger for each six EVs (IEA, 2025), and the number of fast charging points, i.e. more than 50 kilowatts (kW), increased by 40% in 2024.

The electromobility strategy has an ambitious target of at least one charger every 100 kilometres (km) along intercity corridors. In addition, it aims to improve access to charging infrastructure beyond the Santiago metropolitan area. This will require careful planning and investment not only in chargers but also in the electricity network.

Emissions

Transport sector emissions in Chile are projected to decline sharply over the coming decades. In 2024, total CO_2 emissions from transport reached nearly 30 million tonnes of carbon dioxide (Mt CO_2), mostly from passenger and freight road transport. In the APS, emissions fall about 12% by 2035, reflecting the impact of electrification, efficiency gains and technological developments (see Chapter 1). Aviation and shipping account for an increasing share of the remaining emissions (Box 2.2). By 2050, transport emissions in the APS are 90% lower than in 2024, and around 45% of the remaining emissions are from aviation, which today accounts for only 6% of transport sector emissions.

Box 2.2 ▹ Sustainable aviation fuel in Chile

Domestic aviation in Chile currently accounts for just under 2% of total final consumption of energy. This share is projected to rise to close to 2.5% by 2035, driven by a 40% increase in domestic aviation activity. Aviation is considered a hard-to-abate sector as technologies to substantially reduce its emissions are not readily available at scale and are much more expensive than fossil fuels. Today, the main option to reduce emissions from aviation involves blending sustainable aviation fuel (SAF), which is bio-based or synthetic kerosene, with conventional jet fuel. Chile joined the International Civil Aviation Organization (ICAO) ACT-SAF programme in 2023, which focuses on capacity building and SAF market development (ICAO, 2025).

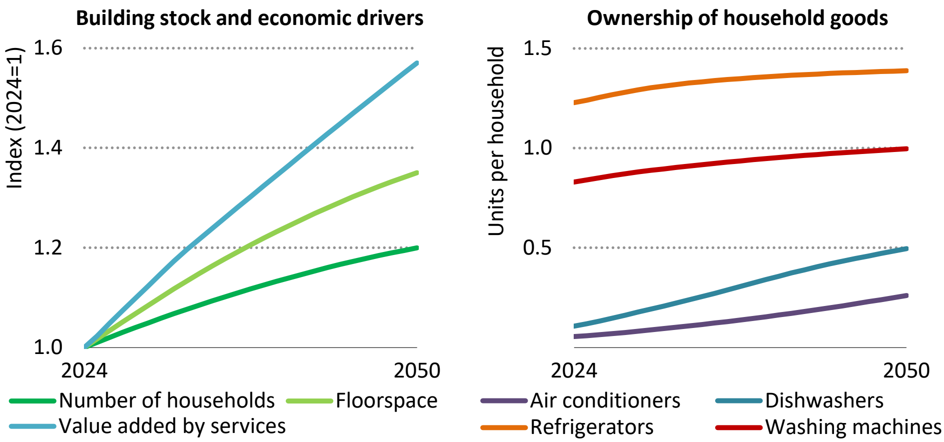
In the APS, the share of SAF in energy demand in aviation in Chile increases from nearly zero today to 5% by 2035 and to over 20% in 2050. This is consistent with the direction of policy in Chile but falls short of the government goal to increase the SAF blending rate to 50% of the fuel used in both domestic and international aviation by 2050. Chile has established ambitious targets for the use of SAF in international flights, as have the European Union, Brazil, Japan and others. There are concerns that the price of SAF production, which can be three- to seven-times higher than conventional jet kerosene, would increase costs for passengers. However, increasing blending shares to APS levels by 2035 would mean only marginal increases in average ticket prices while reducing emissions by 140 kt CO_2 in 2035.

Chile does not currently produce biofuels or SAF, but it plans to establish a pilot SAF production facility by 2030. This facility is expected to use waste oil and other wastes as feedstock and act as a starting point for domestic SAF production and provide an opportunity to quickly scale SAF uptake (Vuelo Limpio, 2024).

2.4.3 Buildings sector

The buildings sector in Chile consumes around 330 PJ annually, of which three-quarters of demand is from the residential sector. Both services and residential in the buildings sector see their energy needs rise in future years (Figure 2.16). The economic output of the services sector is set to increase by nearly 60% by 2050. The number of households is projected to increase by 20% by 2050 and floorspace is set to expand even faster from about 700 million square metres today to increase by 35% by 2050. Ownership levels of household equipment are projected to increase at different rates for various types of appliances. For example, refrigerators and washing machines are already widely owned, whereas dishwasher ownership is at a lower base and increases rapidly. Rising incomes and more cooling degree days, a measure of cooling needs, are set to increase the proportion of households owning air conditioners from 5% today to almost 25% by 2050.

Figure 2.16 ▷ Selected building activity drivers in Chile in the APS, 2024-2050



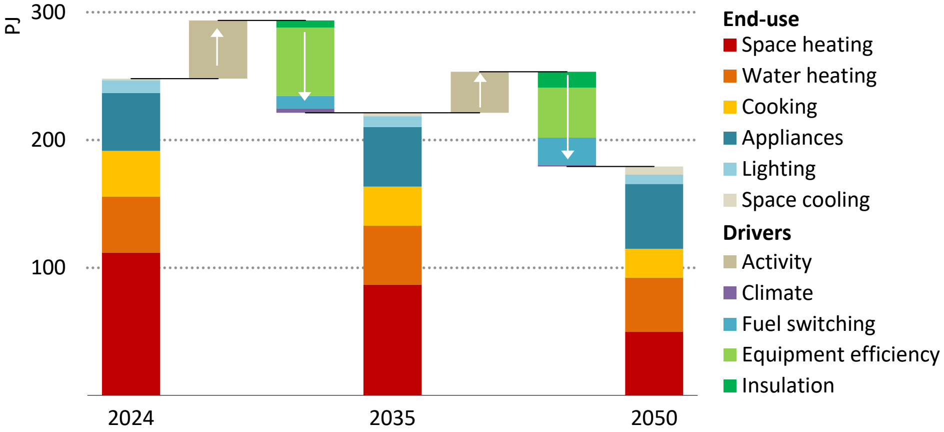
IEA. CC BY 4.0.

Growing economic output, additional building stock and higher levels of equipment ownership are driving up energy demand

Despite this rise in energy service needs, energy demand in the buildings sector is projected to decline in the APS by almost 0.3% per year on average to 2035 and then by 0.5% per year to 2050 as a result of efficiency gains and fuel switching. The services sector sees energy demand increase by 1.8% per year from 2024 to 2035, and then by 1% annually to 2050. The residential sector sees demand fall almost 30% by 2050 compared to today.

The decline in residential energy demand comes mostly from a reduction in space heating energy consumption as a result of a shift away from conventional biomass heaters to more efficient alternatives. Over 40% of the savings from equipment efficiency result from more efficient space heaters. Improved insulation also makes a contribution. The increase in average temperatures contributes to lowering heating needs by 15 PJ by 2050, although the net effect is small as cooling consumption increases by 11 PJ over the same period. The overall effect of these changes is to cut the share of space heating in residential energy demand from 45% today to less than 30% in 2050 in the APS (Figure 2.17).

Figure 2.17 ⊳ Residential energy demand by end-use and drivers of change in Chile in the APS, 2024-2050



IEA. CC BY 4.0.

Efficiency measures outweigh activity growth to 2050, reducing energy demand across residential end-uses except for appliances and space cooling

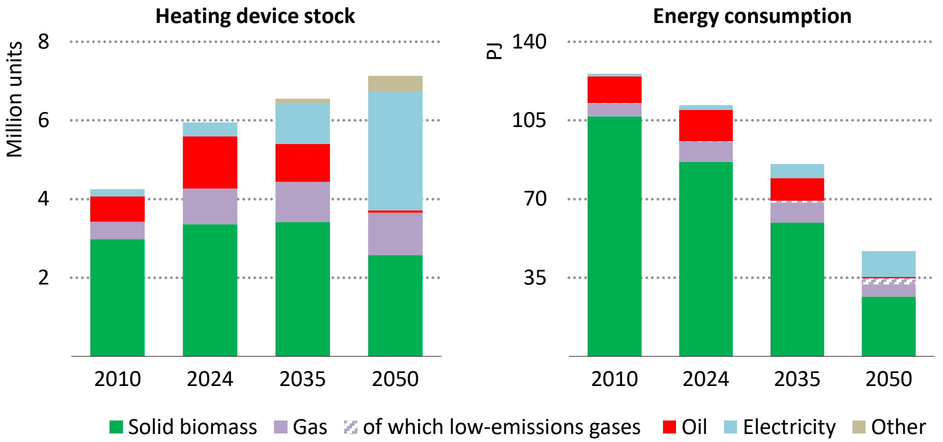
Notes: Insulation includes all measures to improve the energy performance of building envelopes in new construction and by retrofitting existing buildings. Equipment efficiency refers to the technical efficiency of equipment and appliances.

Technology shift in heating – reducing reliance on solid biomass

Space heating is the largest energy end-use in the buildings sector in Chile. Currently most space heating uses biomass. When biomass with a high moisture content is burnt, the combustion is more polluting and less efficient. Inefficient stoves can use twice as much fuel as efficient devices with high-quality biomass to produce the same amount of heat. The APS sees a substantial shift of heating technologies towards more efficient use of bioenergy and significant deployment of electrification in order to meet long-term targets. Today, bioenergy is used in around half of households with heating needs and makes up more than three-quarters of residential heating energy demand (Figure 2.18). In the APS, annual bioenergy consumption for residential space heating is around 65% lower by 2050 than today, and the share of households using bioenergy for heating falls to 35%.

Several targets and policy measures support this shift to more efficient heating. Current laws already regulate the quality of firewood and other wood-based fuels. Regional programmes support the replacement of traditional firewood stoves with more efficient pellet stoves, or a switch to electric heating through heat pumps. The APS sees increased financial support from such government programmes to facilitate the switch to more efficient heating technologies.

Figure 2.18 ▹ Stock of heating devices by energy source and energy consumption for residential space heating in Chile in the APS, 2010-2050



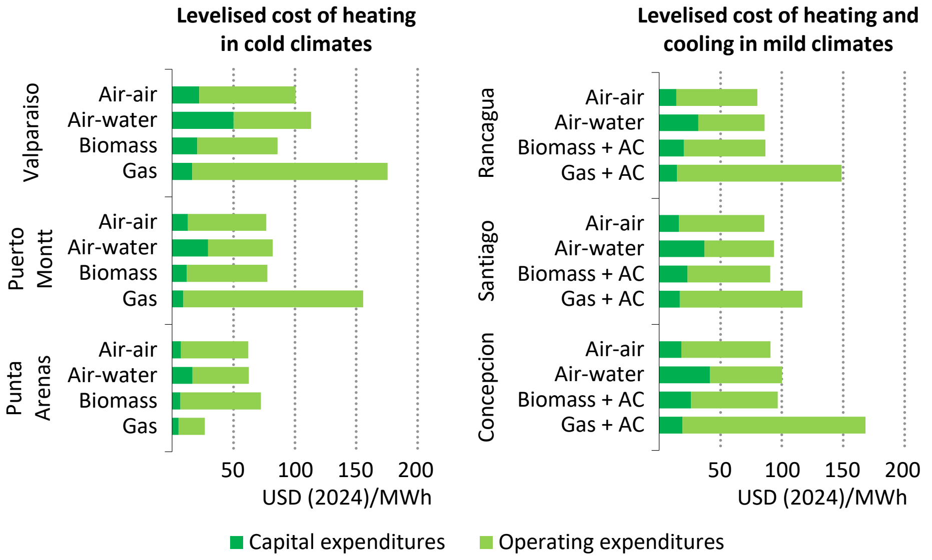
IEA. CC BY 4.0.

Space heating in Chile is set to become more electrified and efficient, shifting away from oil and inefficient biomass heaters

Notes: Low-emissions gases refer to biogas and biomethane. Other includes district heating and geothermal energy.

Options for space heating depend on factors such as annual temperature profiles, geography, fuel prices and population density. Heat pumps are cost competitive over their lifetime with other heating technologies thanks to their high efficiency and low operating costs, and heat pumps with reversible operation are well suited to regions with both heating and cooling needs such as central Chile (Figure 2.19). In the APS, heat pumps and other electric technologies make up more than half of heating sales by 2050. Efficient biomass stoves using fuel with a low moisture content can also be a suitable heating option, especially in areas with less reliable grids. Gas condensing boilers generally have lower upfront costs than heat pumps, but they depend on connection to gas distribution networks, and their lifetime cost competitiveness is sensitive to the relative prices of electricity and gas, which vary by region. The use of natural gas for space heating in households declines 40% by 2050 in the APS due to the switch to more efficient heating equipment, and as an increasing share of biomethane is introduced into gas networks. A small but growing share of heating is also met by geothermal and district heating, which together account for 6% of residential space heating energy consumption by 2050 in the APS.

Figure 2.19 ▷ Levelised cost of space heating and cooling for various technologies in selected cities in Chile



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Heat pumps are cost-competitive in most regions despite the higher upfront cost, while the use of gas is sensitive to regional prices and depends on connection to gas networks

Notes: Air-air = air-to-air heat pump; air-water = air-to-water heat pump; biomass = efficient biomass stove; gas = gas condensing boiler; AC = air conditioner. The levelised cost of heating and cooling estimates the average cost of providing 1 MWh of space heating or cooling over the lifetime of the equipment, considering the capital cost of the equipment plus installation; operating expenditures include the cost of fuel and regular maintenance. The analysis uses heating and cooling degree days averaged for 2020-2024 corresponding to the selected cities. Medium market prices for the equipment in 2024 and projected fuel costs for the remainder of the equipment lifetime under the APS are assumed. Electricity prices are assumed to be uniform throughout Chile. For natural gas, prices are lower in Punta Arenas as regulated by the Gas Services Law for the Magallanes Region and Chilean Antarctica. The price of biomass can vary by location, form (pellets, logs) and type of wood. In this analysis a uniform price of USD 61/MWh is assumed. A lifetime of 17 years is assumed for gas boilers, 15 years for air-to-air and 18 years for groundwater heat pumps. Biomass stoves and air conditioners are assumed to have a lifetime of 10 years.

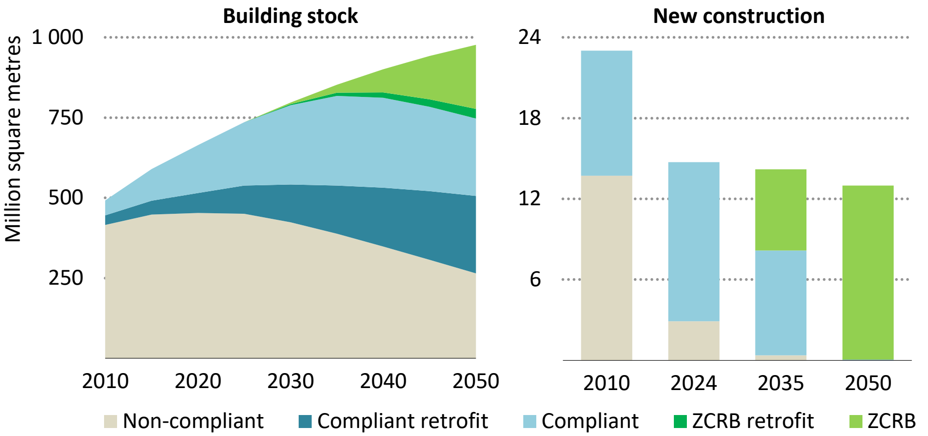
Boosting energy efficiency in buildings

Several policy measures and incentives are in place to improve the energy efficiency of the building stock. Mandatory energy performance standards for new residential buildings, based on Chile's climatic zones, have been in force since 2023. The energy efficiency law also extends energy performance requirements to new public, commercial and office buildings. For existing homes, government subsidies are available to support energy efficiency improvements.

In accordance with the target set out in the National Energy Policy (2022), all new constructions in 2050 will have to meet a highly energy-efficient zero-carbon-ready standard.

Chile has long-standing housing subsidy policies, helping it to achieve a lower share of informal housing than some of its regional peers. In the APS, full roll out of compliance and enforcement policies ensures that nearly all new construction is compliant with building energy performance standards by 2035. Improving the existing building stock also plays an important role to support decarbonisation goals as a majority of households report having little to no insulation. To address this, the APS envisages an annual retrofit rate of 1.3% of existing building floorspace by 2035 which is maintained through to 2050. By 2050, zero-carbon-ready buildings account for nearly a quarter of total floorspace (Figure 2.20).

Figure 2.20 ▷ Building floorspace by envelope type in Chile in the APS, 2010-2050



IEA. CC BY 4.0.

Regulations mandating highly efficient new construction reduce the share of non-compliant envelopes to a quarter of total floorspace by 2050

Note: ZCRB = zero-carbon-ready building, representing a highly energy-efficient building that uses renewable energy directly or an energy supply that can be fully decarbonised, such as electricity or district heat.

Over three-quarters of the electricity consumed in the buildings sector in Chile today is used for appliances and lighting, underscoring the importance of measures to improve their efficiency. Minimum energy performance standards (MEPS) are in place for indoor lighting, air conditioners and refrigerators, which together account for almost 40% of residential electricity demand. In recent years, MEPS for indoor lighting have been progressively strengthened, rising from 40 lumens per watt in 2021 to 85 lumens per watt in 2025. This standard excludes less efficient technologies such as incandescent and halogen bulbs from the market.

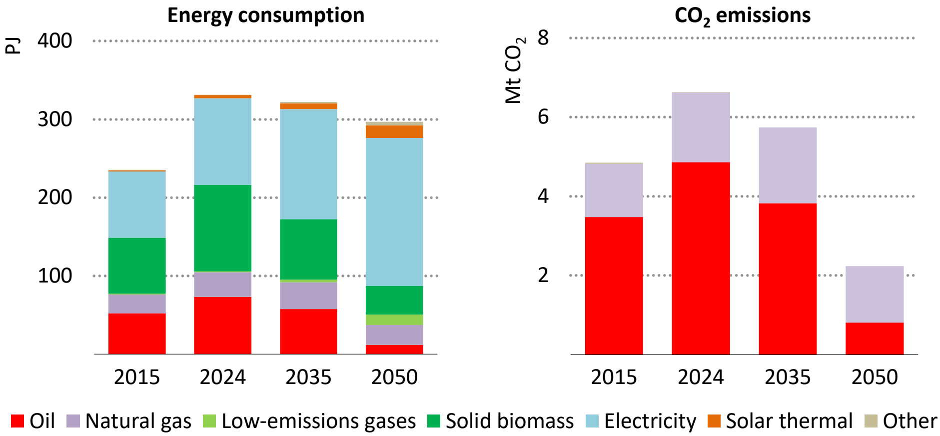
In addition to planned improvements of MEPS for refrigerators, the National Energy Efficiency Plan 2022-2026 aims to strengthen MEPS for air conditioners and to establish standards for televisions, clothes dryers, electric ovens, microwave ovens and dishwashers.

The average efficiency of air conditioners in Chile today is around 3.1.[7] This is below the global average of 3.8 and well below the 6.6 average in Japan, which is a leader in efficiency of air conditioners. In the APS, standards for air conditioners are tightened and by 2035, the efficiency of the air conditioning stock in Chile increases by almost 50%. By 2050, energy consumption per refrigerator is projected to drop by 30% and that for lighting per square metre falls by one-third. Together, these efficiency improvements in the APS avoid 11 TWh of electricity demand for appliances, lighting and air conditioners in buildings by 2050, equivalent to 35% of today's electricity consumption in buildings in Chile.

Emissions trajectory

Energy use in the buildings sector currently generates annual emissions of 6.6 Mt CO_2, which is slightly less than 10% of total energy-related CO_2 emissions in Chile. This level is projected to fall to 2.2 Mt CO_2 by 2050 in the APS (Figure 2.21). The reduction is largely due to the electrification of heating and cooking, improved building efficiencies and increasing use of highly efficient equipment. Over 90% of the decline in emissions reflects a decrease in total oil demand, including in the form of liquefied petroleum gas.

Figure 2.21 ▷ Energy consumption by fuel in buildings and corresponding CO_2 emissions in Chile in the APS, 2015-2050



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CO₂ emissions from the buildings sector fall by two-thirds by 2050 as consumption shifts from oil and natural gas to other fuels and overall energy use declines

Notes: Low-emissions gases refer to biogas and biomethane. Other includes district heat, geothermal energy and coal.

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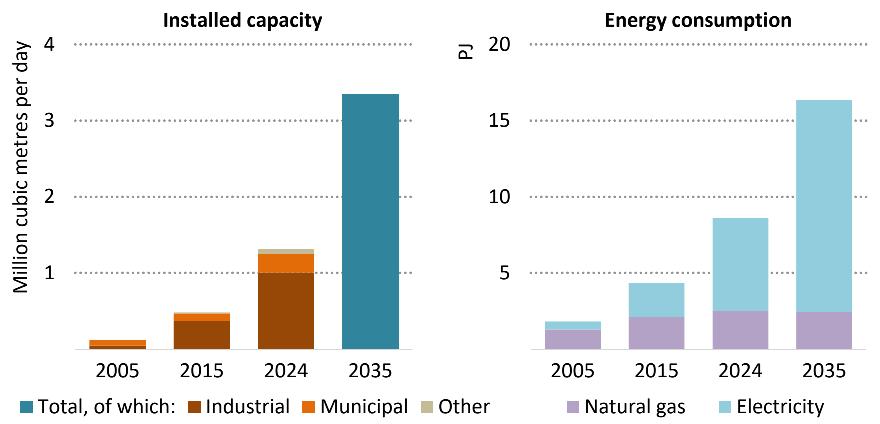
[7] A ratio representing that the air conditioner consumes 1 unit of electricity to produce 3.1 units of cooling.

Box 2.3 ▻ Desalination developments in Chile

Large areas of desert and semi-desert characterise Chile, notably the Atacama Desert in the north. These areas cover around 40% of the country and are home to around 12% of its population. Copper and lithium deposits are concentrated in these areas, and water-intensive mining activities strain the limited freshwater resources. Desalination is increasingly used to meet industrial and household water needs, with over 300 million cubic metres of desalinated water produced annually. A notable recent development is the expansion of the North Desalination plant, which now supplies all of the City of Antofagasta's water, making it the first city in Latin America with over 500 000 inhabitants to rely entirely on desalinated water.

Changes in the climate and rising water needs mean that desalination capacity is expected to increase 2.5-fold by 2035. Some existing plants use fossil fuels for thermal desalination, but reverse osmosis and other membrane-based electrified desalination technologies can be up to ten-times more efficient, and these technologies are set to be used for all net capacity additions. Desalination is expected to consume nearly 4 TWh annually by 2035 in the APS (Figure 2.22). Additionally, pumping water to high-altitude mining operations increases the associated energy use. The cost, energy consumption and environmental impact of brine disposal underline the importance of doing as much as possible to maximise efficient water use and the reuse of treated wastewater.

Figure 2.22 ▻ Installed desalination capacity by end-use and energy consumption by fuel in Chile in the APS, 2005-2035



IEA. CC BY 4.0.

Desalinated water in Chile is mostly used in industry, and demand is rising; the recent use of electric technologies for desalination capacity additions is set to continue

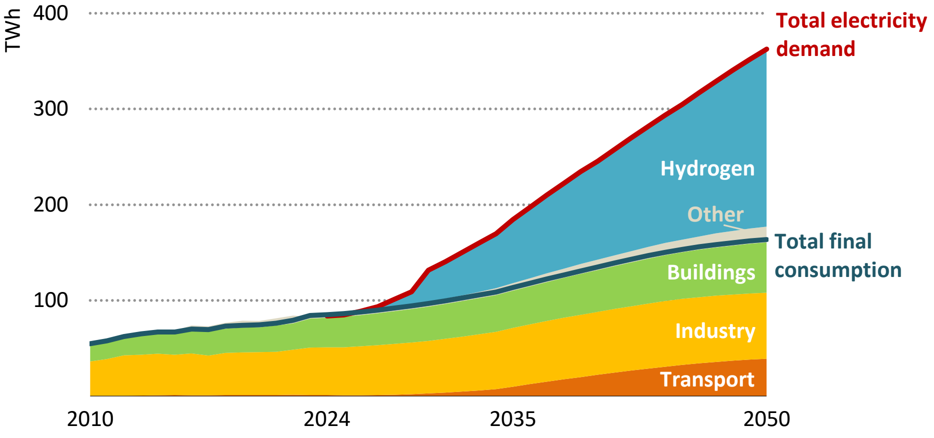
Source: IEA analysis based on DesalData from Global Water Intelligence (GWI, 2023).

2.5 Power sector

2.5.1 Electricity demand

Electricity demand in Chile is set to grow rapidly in the coming years as a result of the electrification of transport and mining, and the production of low-emissions hydrogen (Figure 2.23). In the APS, electricity demand, including on- and off-grid electricity to produce hydrogen, grows at an average of 6% per year to 2050, which is double the rate over the last 15 years, and a faster rate of growth than is seen in other Latin American economies. Average per capita electricity demand rises from 4.2 megawatt-hours per capita (MWh/capita) in 2024 to 9 MWh/capita in 2035. Final electricity demand, without electricity demand for hydrogen production and demand for other energy sector, increases from 84 TWh in 2024 to nearly 120 TWh in 2035 and almost 180 TWh in 2050. When demand for hydrogen production is included, the figures for 2035 and 2050 rise to almost 185 TWh and 365 TWh respectively.

Figure 2.23 ▹ Electricity demand by sector in Chile in the APS, 2010-2050



IEA. CC BY 4.0.

Electrification of transport and deployment of electrolysers for hydrogen production are the main drivers of electricity demand growth

Note: TWh = terawatt-hour. Other includes electricity consumption for the energy sector apart from electricity for hydrogen generation. Data up to and including 2023 are based on officially collected IEA statistics, while projections for 2024 to 2050 are derived from IEA modelling.

Electrification of transport and industry is emerging as a key driver of electricity demand growth in Chile. The rapid uptake of EVs plays an important part, together with further electrification in the mining sector and for heating in buildings, plus the use of electricity to produce low-emissions hydrogen. By 2050, electricity demand for low-emissions hydrogen production via electrolysis is projected to account for half of total electricity consumption in Chile, representing the single largest increase across all demand categories. This surge underscores Chile's pivotal role in the global development of low-emissions hydrogen, which is made possible by its exceptional solar and wind resources, and underpinned by its ambitious national hydrogen strategy.

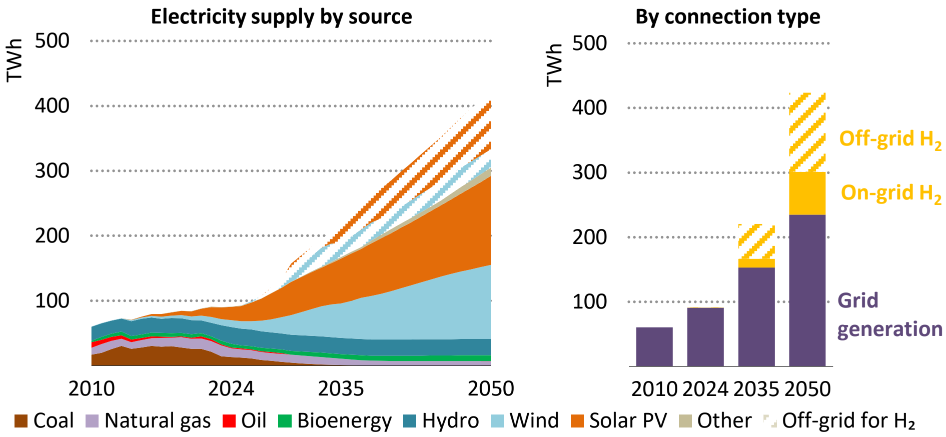
Chile's electricity demand profile is undergoing a significant transformation, driven by structural shifts in consumption patterns and electrification trends. Peak demand more than doubles by 2035 compared to 2024 and grows slightly faster than average electricity demand. EV charging could create additional pressure on the Chilean electricity system, but smart charging can mitigate the impact on peak demand by shifting charging demand to hours when renewables generation is at its maximum. There is also scope to incentivise flexible demand for other uses, such as the production of hydrogen through electrolysis. Demand-side management has the potential to align demand with the production patterns of solar PV generation to make optimal use of available renewable resources and to limit curtailment.

2.5.2 Electricity supply

Electricity generation

The electricity mix is evolving fast in Chile. Coal-fired generation has been in decline since 2018, and renewables generation has increased rapidly. Today, wind and solar PV together account for 34% of total electricity generation, hydropower for over 25%, and coal and natural gas for around 15% each (Figure 2.24).

Figure 2.24 ⊳ Total electricity generation by source and grid connection type in Chile in the APS, 2010-2050



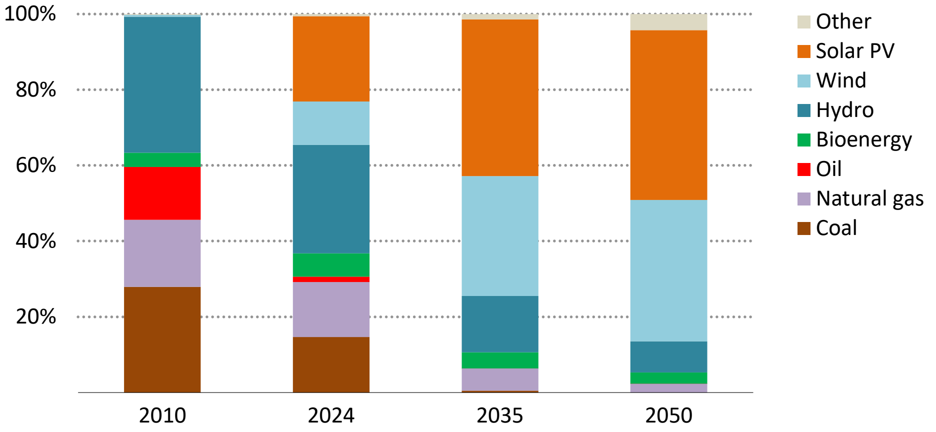
IEA. CC BY 4.0.

Wind and solar PV are the fastest-growing sources of electricity in Chile, and grid-connected sources of electricity account for 70% of total electricity use by 2050

Notes: Other includes concentrating solar power, geothermal, marine, wastes and other sources. Off-grid for H_2 represents renewables generation dedicated to produce off-grid hydrogen.

In the APS, total electricity generation is projected to increase 8% per year on average through to 2035. Nearly all this growth in electricity supply comes from renewables, mostly in the form of utility-scale solar PV and onshore wind (Figure 2.25). Hydropower continues to make a contribution at around its current level, but its share in the mix decreases as total generation increases, and there is a risk that its future use may be constrained by the effects of the changing climate on water availability. Careful management of hydro resources will be essential to maintain security of supply standards and to ensure system reliability. As a result of the growth of renewables, more than 95% of total electricity generation is decarbonised by 2035 in the APS, rising to 98% by 2050.

Figure 2.25 ⊳ Share of total grid electricity generation by source in Chile in the APS, 2010-2050



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Fossil fuels supply 30% of grid-connected generation today but only 6% in 2035; wind and solar PV supply three-quarters of grid-connected generation by 2035

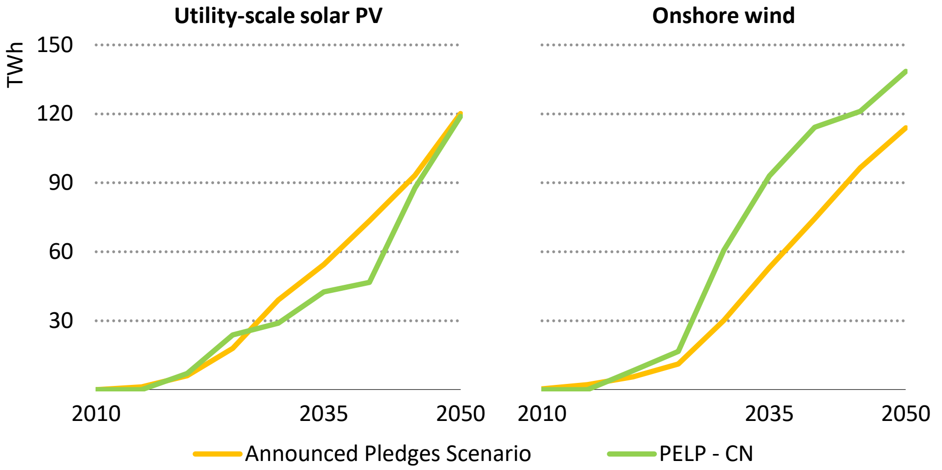
Note: Other includes concentrating solar power, geothermal, marine, wastes and other sources.

As the best renewable resources in Chile are located far from major electricity demand centres, it is likely that a portion of renewables generation will operate off-grid to supply electricity directly to electrolysers for the production of low-emissions hydrogen. As a result, in the APS the share of grid-connected sources of electricity that serve final electricity demand and grid-connected electrolysers decreases from 100% today to 75% by 2035 and then declines slightly to around 70% by 2050. Grid generation increases by 6% per year to 2035, with solar PV and wind accounting for an increasingly large share of generation.

The share of fossil fuels in electricity generation is projected to decline in the APS from 30% of the grid-connected mix in 2024 to 6% in 2035. Coal is gradually phased out by 2040, in line with announced plans. The share of natural gas in the mix declines over time and plateaus in the 2040s, with gas-fired power plants increasingly shifting operations to evenings and early mornings to complement the generation patterns of solar PV and wind. Oil-fired generation, which peaked at 27% in 2008, falls to close to zero by 2035.

Expansion of grid-connected renewable sources of electricity in the APS aligns with the trajectories outlined in Chile's Long-Term Energy Planning (PELP) (Figure 2.26). Generation from solar PV is higher than wind, supported by its excellent solar resources and favourable market conditions (Box 2.4). The growth of both onshore wind and solar PV is boosted by the development of off-grid renewables capacity for low-emissions hydrogen production, which plays an increasingly important role in the energy system in Chile.

Figure 2.26 ▹ Grid-connected solar PV and onshore wind generation in Chile in the PELP Carbon Neutrality scenario and the APS, 2010-2050



Strong growth in solar PV and wind generation in the APS is broadly in line with the Carbon Neutrality scenario in the PELP.

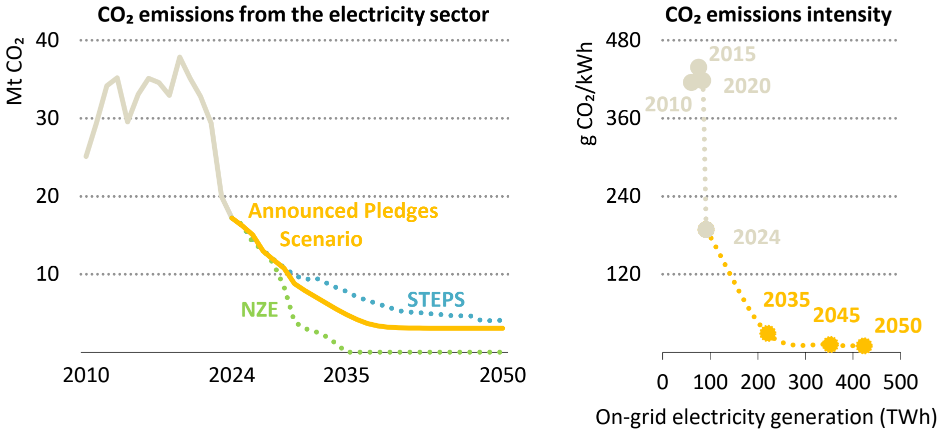
Note: PELP - CN = represents the carbon neutrality scenario in Chile's Long-Term Energy Planning (PELP).

Source: Ministerio de Energia (2025).

CO_2 emissions

CO_2 emissions from the power sector in Chile have already begun to decline from their all-time peak in 2019 of 37.9 Mt, driven by the reduction in coal-fired electricity generation. In 2024, emissions from the power sector totalled 17 Mt, which is less than half the level of 2019, and represented 24% of total energy-related emissions in Chile. In the APS, the power sector is the fastest to decarbonise by 2035, thanks to the growth of renewables and the sharp decline in fossil fuel-based generation, and is responsible for just 10% of all energy-related emissions in 2035 (Figure 2.27). The emissions intensity of the Chilean electricity mix was 189 grammes of carbon dioxide per kilowatt-hour (g CO_2/kWh) in 2024, which is below the country average in the Latin America and the Caribbean (LAC) region, and roughly level with the European Union. In the APS, the CO_2 emission intensity of grid electricity generation in Chile falls sharply to 29 g CO_2/kWh by 2035.

Figure 2.27 ⊳ CO_2 emissions from the electricity sector and emissions intensity of electricity in Chile in the APS, 2010-2050



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CO_2 emissions from grid electricity generation fall rapidly to 2035 due to the phasing out of coal-fired generation and the increasing deployment of renewables

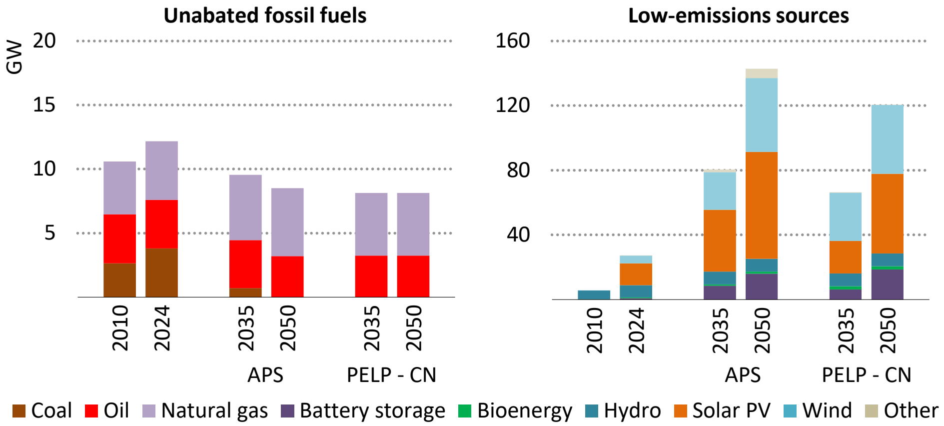
Note: g CO_2/kWh = grammes of carbon dioxide per kilowatt-hour; STEPS = Stated Policies Scenario; NZE = Net Zero Emissions by 2050 Scenario.

Installed power capacity

As demand increases in the APS, installed power capacities in Chile grow for all technologies except coal and oil (Figure 2.28). Chile is committed to phasing out coal-fired generation by 2040 as part of its national decarbonisation strategy. The APS sees coal capacity fall below 1 gigawatt (GW) by 2035. This process began with the 2019 coal phase out plan and was reinforced with the 2025 revisions of emissions standards for thermoelectric plants.

There are several paths to reduce emissions from coal-fired power generation in Chile. They include: repurposing plants to provide flexible load balancing rather than operating in baseload mode; enabling co-firing with low-emissions fuels such as biomass or ammonia; and accelerating plant retirements. Converting coal-fired units to operate on natural gas offers a further transitional option that could lower emissions while helping to maintain system reliability. Although it plays a role in industry, and in power generation in other regions, carbon capture, use and storage is not projected to be part of the portfolio of solutions to decarbonise coal-fired generation in the APS because it is not viewed as a cost-effective or technically mature option. Whatever approach is taken, the deployment of sufficient alternative low-emissions power capacity is essential to enable the transition to take place without compromising electricity security.

Figure 2.28 ⊳ Grid-connected installed capacity by source in Chile in the PELP Carbon Neutrality scenario and the APS, 2010-2050



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In the APS, installed renewable capacity almost triples by 2035, led by rapid growth in solar PV. Battery storage expands in parallel to support the integration of renewables

Notes: GW = gigawatt; APS = Announced Pledges Scenario. PELP - CN = represents the carbon neutrality scenario in Chile's Long-Term Energy Planning (PELP). Other include concentrating solar power, geothermal and marine technologies.

Source: Ministerio de Energia (2025).

Conversion and early retirement of coal-fired power plants are important issues for Chile. They have potential implications for costs and employment and raise security of supply considerations, since coal-fired plants currently provide essential ancillary services such as frequency regulation through inertia, voltage control and spinning reserve. As coal-fired power plants are phased out, ensuring the continued provision of the essential ancillary services they currently provide will be critical to maintain grid stability. This underscores the need for parallel investment in grid infrastructure, storage technologies and advanced grid-forming inverter-based resources, since these are capable of delivering similar system services. Mechanisms such as carbon pricing could help bridge the cost gap and make conversion more attractive to coal plant owners. Measures could be put in place to help those who lose their jobs find new employment (see Chapter 3).

Natural gas power generation capacity increases modestly in the APS to more than 5 GW by 2035, with most investment directed towards open-cycle gas turbines and the conversion of coal-fired power plants to use natural gas. Natural gas-fired power plants increasingly operate during hours of low renewables output to partially replace coal, playing a critical role as a dispatchable source until the 2030s along with hydropower.

Box 2.4 ▹ Costs of renewable energy and fossil fuel technologies in Chile

The levelised cost of electricity (LCOE) is a widely used metric to compare the average cost of electricity generation across technologies over their economic lifetimes. It combines capital investment, financing, fuel, operation and maintenance, and carbon pricing costs into a single cost-per-unit-of-output (Figure 2.29). While useful for comparing technologies on a cost basis, LCOE does not account for the value of each technology and therefore does not explicitly consider the contribution that each technology makes to system adequacy or flexibility, or the costs of integration measures such as grid reinforcement that each technology necessitates. The IEA Global Energy and Climate Model seeks to overcome the shortcomings of the LCOE by applying a value-adjusted LCOE which combines the LCOE and relative system value of each technology, and by including all generation and grid-related costs in an assessment of total system costs.

Despite its limitations, the LCOE metric provides useful information about different technologies. Dispatchable technologies such as combined-cycle gas turbines (CCGT) have LCOEs that reflect both capital and fuel costs. Nuclear has high upfront investment costs but relatively low operating costs, both of which are reflected in the LCOE. Variable renewables, such as solar PV and wind, have no fuel costs: their LCOE depends heavily on the upfront investment and financing costs, together with their performance, which reflects the capacity factor of the renewable resource being utilised.

Renewables in Chile already outperform fossil fuels on a pure cost basis, though a fair comparison across technologies requires accounting for differences in availability and reliability. The LCOE of solar PV is now below USD 50/MWh, with an additional cost of about 10 USD/MWh to pair it with four-hour battery storage with a rated capacity of 20% of the solar PV capacity. In contrast, the LCOE of gas CCGT stands at close to USD 120/MWh, and that of coal at nearly USD 170/MWh. While solar PV is not dispatchable on its own, it can be designed and paired with battery storage to provide firm capacity. For example, a system in Chile combining 600 MW of solar PV (with a 20% capacity factor) with 400 MW/1 600 MWh of battery storage can deliver 100 MW of firm capacity (providing in total a 95% capacity factor, which is comparable with dispatchable power plants) with an LCOE of below USD 110/MWh.[8]

By 2035, the costs of dispatchable solar PV are projected to decline significantly as local markets mature and innovation brings about further improvements in solar PV technology. Falling battery costs reduce the LCOE of solar PV with storage to under USD 75/MWh and to below USD 70/MWh in high-quality resource regions. This is well

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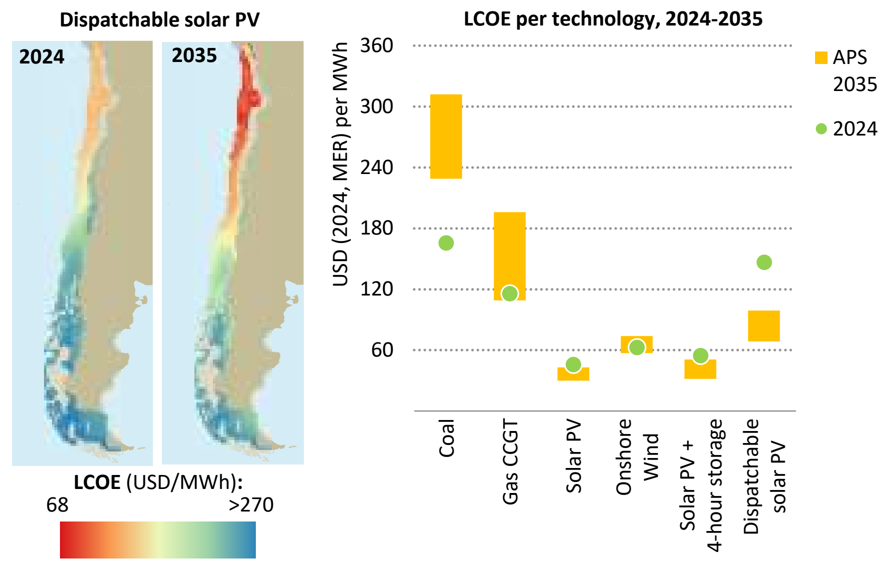
[8] The LCOE for the dispatchable solar PV case is higher than the LCOE figure quoted for the solar PV + four-hour storage case because the system configuration posited here involves a different balance between solar PV and battery storage.

below the USD 110/MWh seen at the low-end of the LCOE range for gas CCGTs in 2024, and the LCOE of gas CCGTs may well rise in the years ahead, given that fuel and CO_2 prices are projected to increase to 2035.

Comparisons of total system costs that include both generation and grid-related costs also provide useful comparisons of different electricity mixes. As detailed in Chapter 4, integrating a growing share of renewables in Chile contributes to lower electricity system costs overall, even when the need for additional grid investments is taken into account.

Figure 2.29 ▷ LCOE of power technologies in Chile in the APS, 2024-2035



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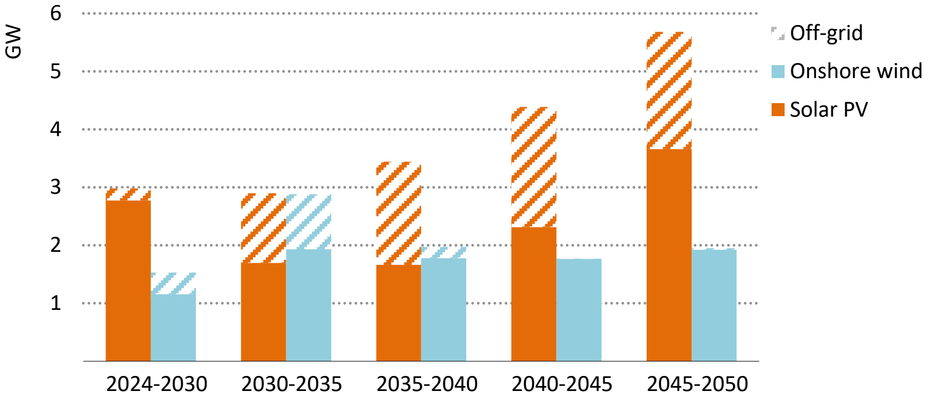
By 2035, dispatchable solar PV (paired with battery storage) is projected to be cost competitive with fossil fuel-based dispatchable generation in many regions of Chile.

Notes: LCOE = levelised cost of electricity; CCGT = combined-cycle gas turbine. All emitting technologies are subject to a carbon tax of USD 5 per tonne of carbon dioxide (t CO_2) in 2024 and assumed USD 160/t CO_2 in 2035. The lower range for coal assumes a 40% capacity factor, while the higher range reflects a 20% capacity factor. For gas CCGT, the lower range assumes a 20% reduction in fuel costs and a 95% capacity factor, whereas the higher range assumes a 20% increase in fuel costs and a 20% capacity factor. The lower range for solar PV is based on capital costs of USD 565/kilowatt (kW), compared to USD 900/kW in the higher range. For onshore wind, the lower range assumes USD 1 420/kW, and the higher range assumes USD 2 000/kW. The solar PV + four-hour storage configuration assumes a 1 megawatt (MW) solar PV plant coupled with 0.2 MW/0.8 MWh battery storage. Dispatchable solar PV refers to the optimal mix of solar PV and utility-scale battery storage (four-hour duration) designed to provide baseload power at a 95% capacity factor, delivering electricity consistently across all hours and days. The lower range assumes solar PV sites with a capacity factor above 20%, while the higher range reflects sites with a capacity factor above 15%. Battery capital costs for four-hour storage are USD 1 022/kW for 2024 and USD 687/kW for 2035 in the APS.

Renewable capacity additions

In 2024, Chile once again broke its record for solar PV installations in the power sector with 2.8 GW of additional capacity. The current project pipeline contains more than 40 GW of additional capacity that has received environmental permitting. In the APS, solar PV capacity in Chile expands faster than any other technology, with average annual grid-connected additions of 2.3 GW until 2035 (Figure 2.30) and 2.7 GW thereafter. Around 30% of the total solar capacity additions projected in the APS by 2035 is expected to be dedicated to off-grid low-emissions hydrogen production, with the intention of making the most of Chile's exceptional solar resources in the Atacama and Antofagasta regions. This drive to produce low-emissions hydrogen receives strong policy support under the National Green Hydrogen Strategy.

Figure 2.30 ▷ Average annual capacity additions for grid-connected and off-grid renewables in Chile in the APS, 2024-2050



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Grid-connected solar PV capacity additions average about 2.5 GW per year through to 2050, while onshore wind additions average around 2 GW annually over the same period

Grid-connected wind capacity in Chile expands significantly in the APS, fivefold by 2035 and reaching over 45 GW by 2050. Onshore wind capacity is projected to increase by an average of 1.5 GW each year to 2035. Chile benefits from favourable wind conditions in both the northern Antofagasta region, which is close to mining and industrial hubs, and the southern Magallanes region (see Chapter 1), which has already attracted major low-emissions hydrogen projects. While Magallanes presents logistical challenges due to its remote location, its exceptional wind resource potential makes it a highly promising area for future development. While Chile does not yet have any operational offshore wind farms, the country is well-positioned to become a regional leader in this sector in the future: its extensive 6 000 km coastline offers promising sites for floating offshore wind development in deep waters, many of which are relatively close to major consumption centres (Box 2.5).

Utility-scale battery storage is being deployed rapidly in Chile to alleviate grid congestion, support the integration of variable renewables and minimise curtailment of renewables generation. In 2022, Chile passed legislation that allows storage technologies to participate in electricity markets for energy arbitrage and capacity payments. Batteries are particularly important in Chile because the pace of transmission system infrastructure development alone is not enough to cope with the increasing penetration of renewables generation located far from demand centres. In 2024, an estimated 6.2 TWh of renewables electricity was curtailed, representing around 20% of total solar PV and wind generation. Battery storage can help reduce curtailment levels and support the integration of variable renewables.

The amount of battery storage required depends on the availability of other sources of flexibility, including from demand-side responses or hydrogen electrolysers (Instituto Sistemas Complejos de Ingeniería, 2024). Careful planning of storage capacity that takes account of the location of renewable plants and grid constraints is critical to enable efficient integration of variable sources and manage short-term flexibility; ensure market access for batteries and provide clear long-term signals on profitability, which are key to securing investment and sustaining revenues for this technology. In the APS, battery storage reaches 8 GW and 19 GWh of storage by 2035, equivalent to about a fifth of the solar PV capacity projected by that date. Growth continues out to 2050, by which time it reaches 16 GW and 35 GWh of storage.

Around-the-clock renewable sources of power have an important role to play alongside variable solar PV and wind. Hydropower has a valuable role in the power system today, and the country's large reservoirs are important for seasonal flexibility, but the APS sees only limited expansion of this source of power. Chile's existing capacity is on average over 35 years old, social resistance to large-scale projects constrains new developments and climate change is expected to affect water inflows (see Chapter 4). These points reinforce the importance of optimising water management and storage. Although batteries dominate storage in the APS, pumped hydro offers a unique long-duration (eight hours plus) storage solution, particularly along the coast. Pumped hydro could play a supporting role alongside batteries in managing short-term hour-to-hour variability, which is poised to increase from 2 to 7 GW by 2035, double the system's overall growth (see Chapter 3 on electricity security).

Emerging renewable technologies like geothermal and concentrating solar power (CSP) could provide round-the-clock generation to support variable renewables. Chile has substantial geothermal potential along the spine of the Andes Mountains, but little development so far. High upfront costs, geological uncertainty and long project timelines have hindered traditional approaches to geothermal development. However, next-generation geothermal technologies that benefit from oil and gas drilling techniques could open new opportunities (IEA, 2024).

CSP offers promise for the future, given the country's world-class solar resources in the Atacama Desert. Long development timelines have slowed momentum for this nascent technology but strengthened policy support that recognises the system value of long-duration storage could help unlock a role for CSP to achieve decarbonisation targets in Chile. Both geothermal and CSP struggle to compete against very low-cost solar PV, meaning they play only a marginal role in decarbonising the power sector in the APS.

Box 2.5 ⊳ Unlocking Latin America's offshore wind potential

Floating offshore wind is a branch of the offshore wind sector distinguished by its ability to be deployed in waters more than 50–60 metres deep which are beyond the reach of conventional bottom-fixed turbines (IEA, 2019). The technology is steadily maturing, with pre-commercial projects already operational in the North Sea, Atlantic Ocean, and Mediterranean Sea. As of 2024, floating wind remain a nascent industry, with only 0.1-0.3 GW in operation worldwide. Turbine sizes for floating offshore wind developments are usually around 8 MW per floater, compared to 10-15 MW for today's average bottom-fixed offshore wind power installation, but the gap is closing.

Latin America has just begun exploring the potential for offshore wind. The region benefits from a long coastline and wind resources that offer significant potential. Although the technology readiness for floating offshore wind power platforms in Latin America remains low, there are clear synergies with the existing regional oil and gas supply chains. To date, only small-scale environmental monitoring buoys and test floaters have been deployed. There are no operating offshore wind farms, either fixed or floating, in the region.

Yet recently, interest has surged and the Energy Industries Council has recorded 108 announced projects with a combined capacity of almost 230 GW. Approximately 75% of these projects are concentrated along the Atlantic coast of Brazil, and a significant number are in Colombia. While many of these projects are speculative, they reflect ambition which is largely motivated by a desire on the part of Brazil and Colombia to leverage their oil and gas expertise in order to support offshore wind power development. Brazil is advancing legislation to support offshore wind through contract-for-difference mechanisms and is the only country in the region with domestic manufacturing of nacelles and turbine blades, positioning it as a potential regional hub. Colombia is progressing with auction schedules, seabed allocations and fiscal incentives to attract investment. Its energy roadmap explicitly includes pilot and demonstration projects for offshore wind as a stepping stone to build local knowledge before scaling up auctions. It also has a dedicated offshore wind roadmap (Minenergía, 2022).

Although governments increasingly recognise the potential for offshore wind power development, work on long-term plans and detailed regulatory frameworks is at an early stage. Investment at this stage focus on feasibility studies, site surveys and consortium-building rather than final investment decisions. Attracting foreign investment is a critical challenge for offshore wind power development in Latin America. Norwegian, Spanish and United Kingdom firms are investing in Chile. As well, other European companies, such as Equinor, Acciona, Shell and CIP, have filed proposals for offshore leases in Brazil.

International development banks and organisations are actively supporting studies and capacity building in the region.

The Pacific coast of Chile offers strong wind resources in deep waters close to shore as well as to major electricity demand centres, and the country is poised to become one of the first in Latin America to develop floating offshore wind. In August 2024, UK-based developer 17 Energy and Chilean firm SC Power announced plans to build a 960 MW floating offshore wind farm off the coast of the Biobío region – the Viento Azul Biobío project – with operations expected to begin in 2032. Later that year, the Norwegian developers Deep Wind Offshore and 17 Energy also announced gigawatt-scale fixed and floating offshore wind projects in Chile. No dedicated offshore wind power law or regulatory regime exists in Chile yet, but the country does already have in place a well-defined regulatory regime for maritime concessions.

While recent developments underline the potential of offshore wind, there is still a long way to go. Key challenges for projects include the absence of precedent, the need for grid infrastructure upgrades to integrate offshore wind, together with port enhancements to accommodate large turbines and floating platforms, and the need for operators to comply with environmental safeguards to protect fisheries and marine ecosystems. Offshore wind power in Chile represents a medium- to long-term opportunity. Its prospects depend on supportive policies and regulatory frameworks, further technological development, and costs, but it could potentially provide renewables generation close to major demand centres.

Electricity grids

Electricity network development is pivotal to enable Chile to meet its decarbonisation targets and ensure long-term energy security. In the APS, annual grid additions increase fourfold by 2035, with around 85% of the increase driven by network expansion and the remaining 15% by the need for some existing assets to be replaced. Total grid length reaches 300 000 km by 2035 and over 700 000 km by 2050. The increase to 2035 involves development of 6 000 km in transmission and 80 000 km in distribution networks, reflecting the importance of connecting decentralised renewables generation and increasingly electrified end-uses. Grid development is closely tied to the deployment and geographical distribution of battery storage.

In addition to new transmission corridors, modernisation of existing substations, digital control systems, and advanced grid equipment such as flexible alternating current (AC) transmission systems (FACTS) including synchronous condensers (SVC) and enhanced static synchronous compensator (eSTATCOM) will be essential to help regulate voltage, ensure inertia support and maintain system stability under high renewables penetration. The needed investment is discussed in detail in Chapter 3.

Grid resilience has become a central concern, especially following the large-scale blackout in February 2025 (see Box 1.1) and the rise in disruptions to distribution networks caused by extreme weather events such as landslides and storms. Both the blackout and recent disruptions underscore the need to strengthen the grid for both transmission and distribution systems, including enhancing redundancy, improving real-time visibility and response protocols, and strengthening system recovery capabilities (Chapter 4). Chile is addressing these concerns with regulatory reforms to improve the resilience of the power system.

Annual distribution grid additions are set to increase nearly fivefold by 2035, driven by rising electricity demand. Chile will get the maximum value out of these grid additions if it accompanies them with regulatory reforms and other measures to spur investment in smarter, more resilient networks, integrate distributed renewables and new uses like solar, storage and EVs into grid operations and management, and boost the reliability and climate resilience of local networks. Updating regulations to facilitate the deployment of distributed resources and battery storage will also help balance generation and loads locally, and enhance grid stability, while incentivising flexible demand through granular time-of-use tariffs and accelerating smart meter roll out could ease local congestion and reduce pressure on electricity prices.

In the APS, transmission grid development is partly driven by the need to integrate renewables through new high-capacity corridors linking resource-rich regions to demand centres. The expansion plan, led by the National Electricity System (SEN), targets congestion and security risks with a programme of upgrades to boost capacity and reliability (Coordinador Eléctrico Nacional, 2025). A flagship project is the Kimal–Lo Aguirre high voltage direct current line, Chile’s first ±600 kilovolt (kV) system, which will stretch 1 500 km and connect Antofagasta with Santiago, enabling solar exports from the north. This is due to be completed in 2029. Further reinforcements in the north-central corridor are needed to avoid saturation of AC lines, while the central-south corridor faces growing pressure from wind power development. In the far south, historically a weak segment, planned onshore wind projects will require significant grid upgrades to connect remote areas to the main system.

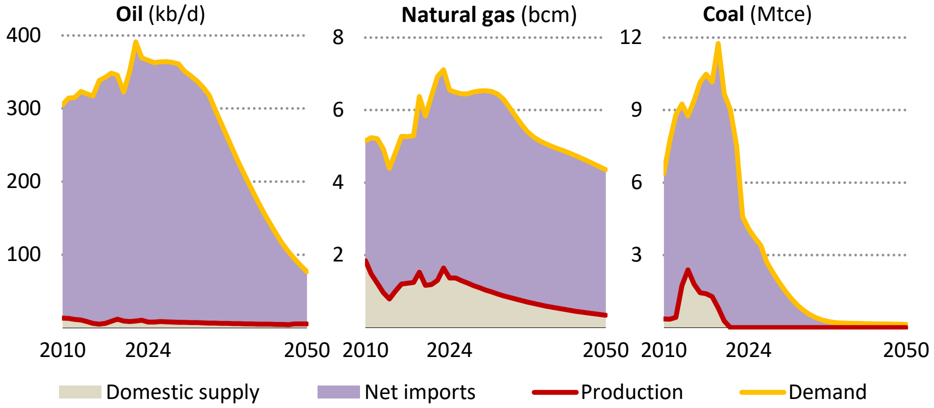
Chile is taking action to accelerate transmission development and ease long-standing bottlenecks. Its Energy Transition Law of 2024 empowers authorities to fast-track priority projects, simplify permitting and step up the planning process for urgent works. It also assigns incumbents more responsibility for timely execution. By reducing red tape and tackling approval hurdles, it aims to shorten lead times and better align grid capacity with fast-growing renewables generation.

On the regional front, Chile aims to strengthen cross-border links and expand ties with Argentina and Peru by engaging in initiatives like the Andean Electrical Interconnection System (SINEA) and the Energy Integration System of the Southern Cone Countries (SIESUR). Upgrades to the 345 kV Chile–Argentina line and new corridors could add several hundred MW of exchange, boosting regional integration and improving system flexibility. These projects support Chile’s vision of becoming a Southern Cone energy hub. They face challenges, including lengthy permitting processes, the need for harmonised technical standards, and co-ordination across different electricity markets. However, they have the potential to improve grid resilience, lower electricity costs and enhance the integration of renewable energy across borders.

2.6 Fossil fuel supply

Domestic oil and natural gas production comes almost entirely from a few fields in the Magallanes Basin in the far south, where output has been declining in recent years. As a result, Chile depends heavily on imports, sourcing about 98% of its oil and 80% of its natural gas from abroad. Pipeline imports of natural gas from Argentina are complemented by liquefied natural gas shipments through the Quintero and Mejillones terminals.

Figure 2.31 ▷ Oil, natural gas and coal production, demand and net imports in Chile in the APS, 2010-2050



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Chile currently imports about 98% of its oil, about 80% of its natural gas and all its coal, but falling demand means that imports decline significantly

The APS sees small additional developments within existing hydrocarbon fields. These help slow decline, but they do not alter the overall outlook of falling production as existing fields mature. Yet declining fossil fuel consumption reduces net imports over time, even with less domestic production (Figure 2.31). In the APS, oil imports fall from 360 thousand barrels per day (kb/d) in 2024 to around 300 kb/d by 2035 and below 75 kb/d by 2050, while natural gas imports fall from 5 billion cubic metres (bcm) in 2024 to 4 bcm in 2050.

The last coal mine in Chile closed in 2020 in line with the phase-out policy. All coal consumed today is imported. As coal demand continues to fall with the retirement of coal-fired power plants, imports in the APS drop from around 4 Mtce today to 0.5 Mtce in 2035 and close to zero in 2050.

Implications of the energy transition pathway

Strategies to ensure a just transition

SUMMARY

- Chile's ambitious emissions reductions goals have implications well beyond its energy sector. The transition modelled in the Announced Pledges Scenario (APS) sets out a possible avenue that reduces dependence on imported energy, lowers household energy bills, creates new jobs and improves air quality. Achieving it requires significantly enhanced public and private investment, big changes in the electricity system and effective strategies to address changes in patterns of employment in the energy sector.
- In the APS, annual average investment in the energy sector reaches nearly US dollars (USD) 13 billion over the period to 2035, up from USD 4.5 billion over the last decade. Investment in power more than doubles in the next decade. Investment in electricity networks become more significant, representing 40% of total power sector investment in the period from 2035 to 2050. In the next decade, investment in natural gas supply grows slightly, while other fossil fuels fall, and low-emissions hydrogen comes to represent the majority of investment in energy supply.
- Chile has achieved near universal electricity access, but issues of energy affordability and poverty remain. Energy efficiency improvements in the APS reduce demand and more than halve household energy bills by 2050, although the upfront costs of efficient, low-carbon equipment could hinder their uptake in low-income households without appropriate support policies. Annual investment in end-uses reaches more than USD 3 billion in the coming decade, seven times the 2015-2024 average. The vast majority is directed towards efficiency and electrification, particularly in the transport sector. Electricity system costs per unit of electricity consumed come down as the variable cost of fossil fuels is replaced by the largely fixed of renewables.
- Today almost all fossil fuels used in Chile are imported. Those are reduced by 72% by 2050 in the APS, which cuts import costs from USD 14 billion to USD 3 billion and enhances energy security. Development of low-emissions hydrogen production projected in the APS diversifies options and creates new export opportunities. Replacing imported fossil fuels with domestic renewables and broadening electrification requires investment in grids, demand-response management, dispatchable generation and electricity storage.
- Air pollution is responsible for about 5 000 premature deaths each year in Chile, bringing a high human cost. Faster and deeper cuts in emissions from the transport and industry sectors and particularly for residential heating in the APS, significantly improve air quality and reduce the cumulative number of premature deaths.

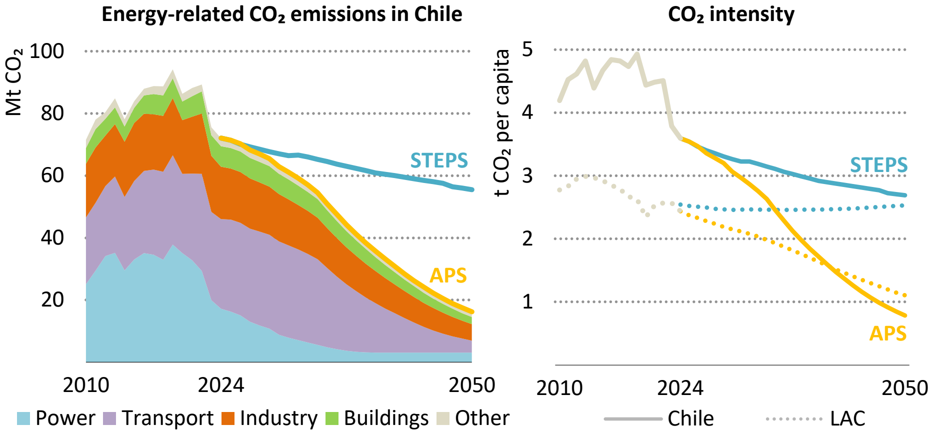
3.1 Introduction

Chile's climate ambitions imply an economic transformation broader than the energy sector that presents challenges but also offers new opportunities. This chapter explores the key levers for emissions reductions and associated benefits such as lower energy imports, enhanced energy security, reduced household energy bills and better air quality. It also discusses potential challenges such as the need for massive investment and changing patterns of employment in the energy sector.

3.2 Net zero emissions pathway in the Announced Pledges Scenario

Energy-related carbon dioxide (CO_2) emissions in Chile in the Announced Pledges Scenario (APS) follow a decisive decarbonisation path that reflects its ambitious energy and climate commitments. Its energy-related CO_2 emissions peaked in 2019 at 94 million tonnes of carbon dioxide (Mt CO_2) and have declined since to around 72 Mt CO_2 in 2024. In the APS, this downward trajectory continues through to mid-century, with emissions falling by 45% from their peak to 51 Mt CO_2 in 2035 and decreasing by more than 80% to just over 16 Mt CO_2 by 2050 (Figure 3.1). This is well below the level of reduction achieved with enacted policies as reflected in the Stated Policies Scenario (STEPS) in which emissions reach 55 Mt by 2050.

Figure 3.1 ▷ Energy-related CO_2 emissions by sector and emissions per capita in Chile and LAC in the STEPS and APS, 2010-2050



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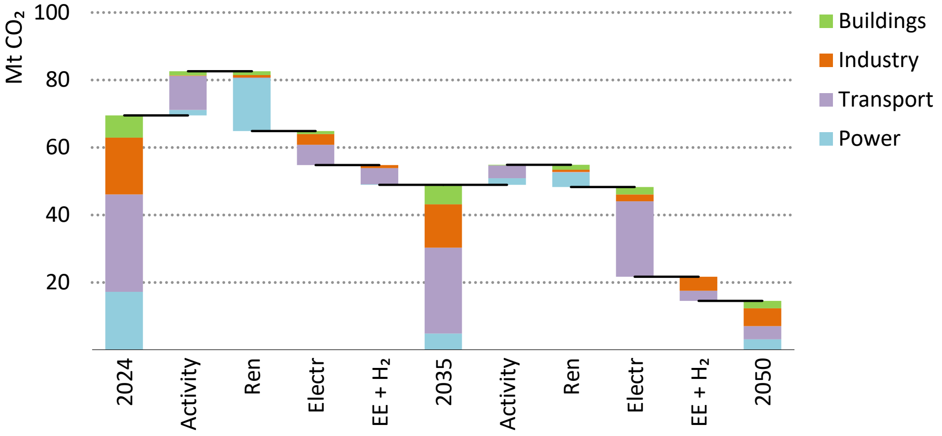
Accelerated decarbonisation of power and transport reduces CO_2 emissions to one-fifth of their current level by 2050, bringing emissions below 1 tonne per capita in Chile

Note: Mt CO_2 = million tonnes of carbon dioxide; t CO_2 = tonnes of carbon dioxide; STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; LAC = Latin America and the Caribbean.

In the APS, emissions from the power sector fall more than 70% by 2035 as renewables generation ramps up, and emissions fall further to just 3 Mt CO_2 by 2050 – an 80% decline from 2024 levels. Transport sector emissions follow a more gradual initial trajectory, remaining relatively stable until 2030, then falling 12% from 2024 levels by 2035 as electric vehicle (EV) adoption accelerates, and nearly 90% from 2024 levels by 2050 as EVs dominate the roads. Industry sector emissions fall by 24% from 2024 levels by 2035 and by nearly 70% by 2050. These reductions in industry reflect electrification in mining, a 35% improvement in energy intensity, and a rise in the use of bioenergy, which meets 73% of energy used in pulp and paper production and 31% of cement by 2050. By 2050, carbon capture, utilisation and storage capture 1.1 Mt CO_2 per year, and low-emissions hydrogen supplies 7% of energy demand in the industry sector. Emissions from the buildings sector decline 13% by 2035 and 66% by 2050 compared to 2024 levels. These reductions stem from the widespread electrification of heating and cooking, improved building efficiency standards, and the uptake of heat pumps and efficient appliances.

In the STEPS, emissions decline by around 10% in 2035 compared to 2024 levels. Most of those reductions stem from the power sector, while emissions from industry, transport and buildings remain broadly constant up to 2035.

Figure 3.2 ⊳ **CO_2 emissions reductions by mitigation measure in Chile in the APS, 2024-2050**



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Renewable penetration and direct electrification, especially in transport, are the main drivers of CO_2 emission reductions in the APS by 2050

Note: Activity = increasing activity; Ren = renewables; Electr = electrification; EE + H_2 = energy efficiency and fuel switching to hydrogen.

In the APS, renewables account for approximately 40% of emissions reductions to 2050 by displacing fossil fuels in power generation, which is more than enough to compensate for the overall increase in energy services demand fuelled by growing economic activity. End-use sectors also contribute through efficiency measures and fuel switching, with hydrogen providing 10% of the emissions reductions in industry and transport. Over time, electrification and other forms of fuel switching play an increasingly important role to reduce emissions across end-uses, underscoring the integrated nature of Chile's decarbonisation strategy. Before 2035, the phase-out of fossil fuel generation in power is the most important lever for emissions reduction. After 2035, electrification becomes a more important driver for reducing emissions in the roadmap to 2050 (Figure 3.2).

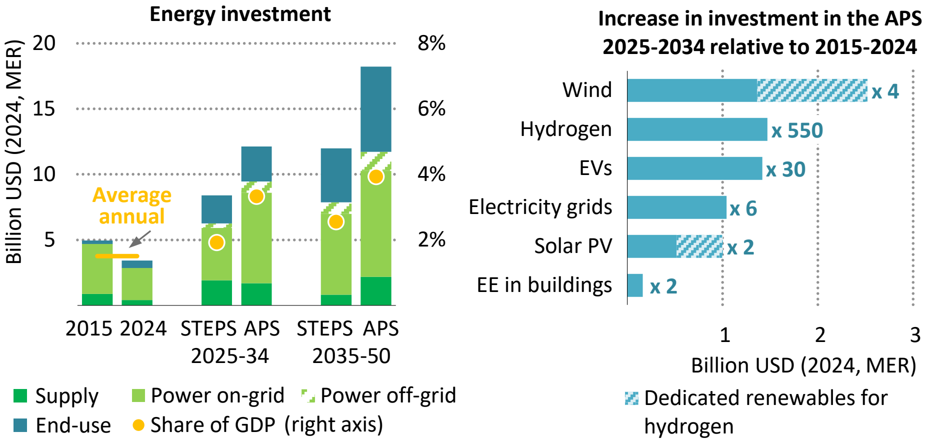
3.3 Investment needs

Overall investment in energy in Chile is set to rise sharply over the coming decade in the APS, reflecting the country's ambitious push for clean energy technology deployment (Figure 3.3). Annual average investment reaches nearly US dollars (USD) 13 billion over the period to 2035, a substantial increase from the USD 4.5 billion observed over the past decade. This surge corresponds to a rise in energy investment from 1.4% to 3.3% of Chile's gross domestic product (GDP). Growth is driven by the large-scale rollout of renewables, grid development, electrification and the expansion of hydrogen supply infrastructure, including electrolysers. Scaling up investment will be a major challenge, given the significant amount required and challenges to mobilise diverse sources of financing. Investments are also increasing in the STEPS, though at a slower pace than in the APS. In the power and supply sectors, this difference reflects the stronger development of renewable generation and hydrogen production under the APS. The APS further illustrates additional efforts to boost electrification in end-use sectors, resulting in a greater reduction in oil import bills compared with the STEPS (see 3.5.1).

Investment in the power sector accounts for 60% of total energy investment by 2035, although a portion of energy spending on renewables is allocated to off-grid capacity for hydrogen production, highlighting the cross-sectoral nature of the energy transition. More than 80% of the low-emissions hydrogen production in the APS is intended for export markets, and USD 2 billion of annual investment is for renewables generation and hydrogen infrastructure dedicated to supporting these exports.

In the APS, wind power sees the largest increase in investment: it rises to more than USD 3 billion per year by 2035, up from less than USD 1 billion today. Hydrogen supply ranks second in terms of direct investment growth in the coming decade. However, when the dedicated renewables electricity capacity required for hydrogen production is added in, it comes first in terms of total increase in investment. Around half of the investment in hydrogen supply in the APS is allocated to renewables generation capacity, with the remainder directed towards infrastructure, electrolysers and fuel production.

Figure 3.3 ▷ **Annual energy investment by sector, 2015 and 2024, and by scenario to 2050, and incremental investment to 2035 in Chile the APS**



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Energy investment triples over the next decade in the APS to about 3.3% of GDP by 2035, with wind, EVs and hydrogen requiring the largest scale-up

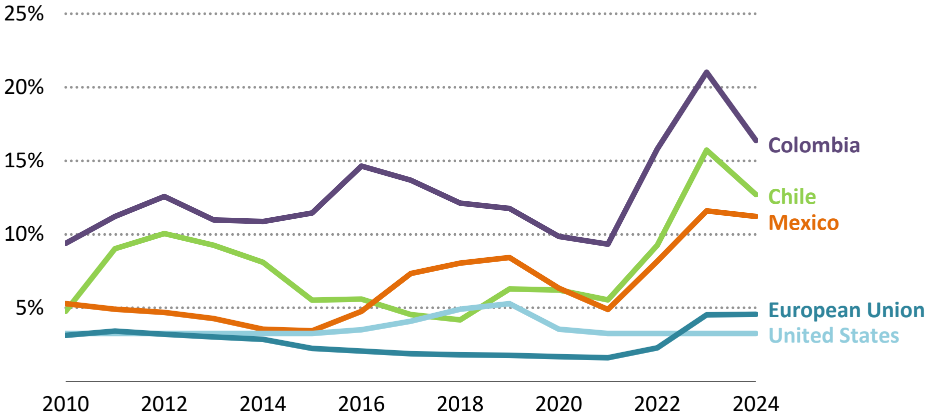
Notes: USD = US dollar; MER = market exchange rate; EE = energy efficiency; EVs = electric vehicles. Power off-grid relates to off-grid generation for hydrogen production. Hydrogen includes all investment related to hydrogen and hydrogen-based fuels supply (including electrolysers), without accounting for dedicated renewable generation.

Sources of financing

Chile's energy transition in the next decade requires a significant increase in investment across the power sector, energy supply and end-use applications, including for electrification and efficiency improvements. Mobilising capital from private and international investors at rates that allow projects to remain cost effective is a core challenge, as financing costs in Chile and the Latin America and the Caribbean (LAC) region are considerably higher than in advanced economies. Average financing costs were around 13% in 2024, more than double the level observed in 2021, creating a difficult environment for capital-intensive clean energy projects to achieve adequate returns on investment (Figure 3.4).

Elevated lending rates reflect both country-specific and sectoral risks that are embedded in the cost of capital through a base rate and a project premium. For technologies such as solar photovoltaics (PV), wind or electrolysers, which rely heavily on debt financing due to their fixed costs and revenue structures, high borrowing costs represent a critical barrier to deployment. Overcoming these hurdles requires a comprehensive approach that addresses multiple dimensions of risk simultaneously. Chile has several strengths to build upon. It has a proven track record of attracting foreign investment in energy, and it consistently ranks among the most stable investment destinations in the LAC region. It has also implemented competitive renewable energy auctions and long-term contracts, providing certainty to developers and reducing financing costs (IEA and OLADE, 2025). Such mechanisms are particularly important for renewables and storage projects because they allow potential investors to form a clear view about future revenues.

Figure 3.4 ▻ Lending rates to corporations in selected countries/regions, 2010-2024



IEA. CC BY 4.0.

High financing costs in Chile could be a major barrier to scaling up clean energy investment

Note: European Union lending rates are computed using a weighted average according to gross domestic product (GDP).

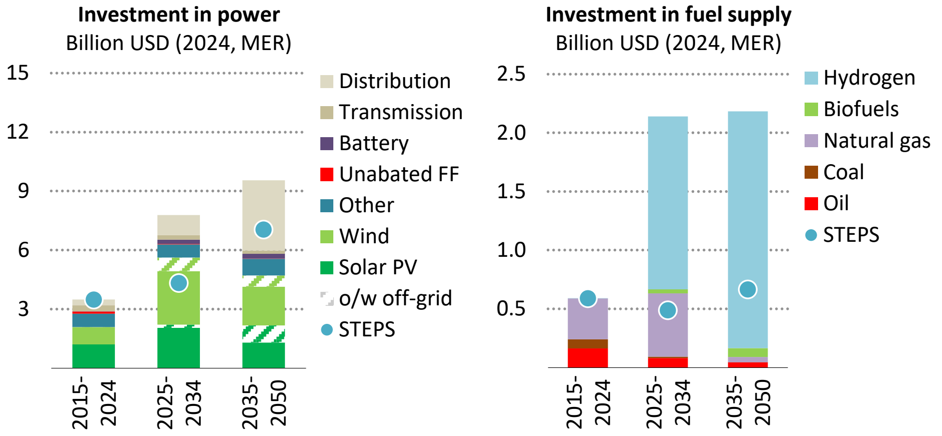
Sources: IEA analysis based on World Bank (2025), European Central Bank (2025), US Federal Reserve (2025) and Banco Central Chile (2025).

Strengthening regulatory certainty and streamlining permitting processes is essential to reduce project risks and improve investor confidence. In parallel, the development of green bond markets can help diversify funding sources and attract institutional investors to provide access to longer term and lower cost capital. These measures need to be complemented by investment in electricity grids to ensure quality of service and reliability, and in the provision of system flexibility, including demand response and storage, to ensure that energy from variable renewables can be reliably integrated into the electricity system. The combined implementation of these measures is key to creating a financing environment capable of supporting Chile's clean energy transition.

Investment in the power sector and fuel supply

Investment in the power sector needs to rise significantly to support Chile's energy transition (Figure 3.5). In the APS, average annual investment in power overall more than doubles compared to the past decade. It reaches an average of nearly USD 8 billion per year over the next decade, with nearly all investment before 2035 directed toward low-emissions electricity generation and grids.

Figure 3.5 ▷ Average annual investment in the power sector and fuel supply by type in Chile in the APS and STEPS, 2015-2050



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Investment needs to increase faster in the APS for low-emissions sources in the power sector and in grids compared to the STEPS

Notes: MER = market exchange rate; FF = fossil fuels. Other includes investment for renewables except solar PV and wind. o/w off-grid = of which off-grid. Power off-grid relates to off-grid generation for hydrogen production.

It is useful to separately consider investment in grid-connected generation and in infrastructure, including grids and battery storage, from off-grid generation meant to supply electrolysers for hydrogen production. Excluding investment for off-grid generation for hydrogen, power sector investment in the APS averages USD 7 billion per year by 2035, of which grids represent 20%. Grid infrastructure accounts for 40% of total investment needs between 2035 and 2050, with distribution taking the largest proportion, mostly because of increasing electrification and therefore additional electricity demand. In the STEPS, grid investment continues to rise steadily, representing about one-third of total power sector investment needs between 2035 and 2050. In the APS, accelerated investment underscores the push for deeper electrification and greater renewable integration.

Storage and flexibility also require additional investment, particularly utility-scale batteries. Investment in hydropower and other renewables in the APS is stable through to 2050 in order to maintain the current level of hydro generation.

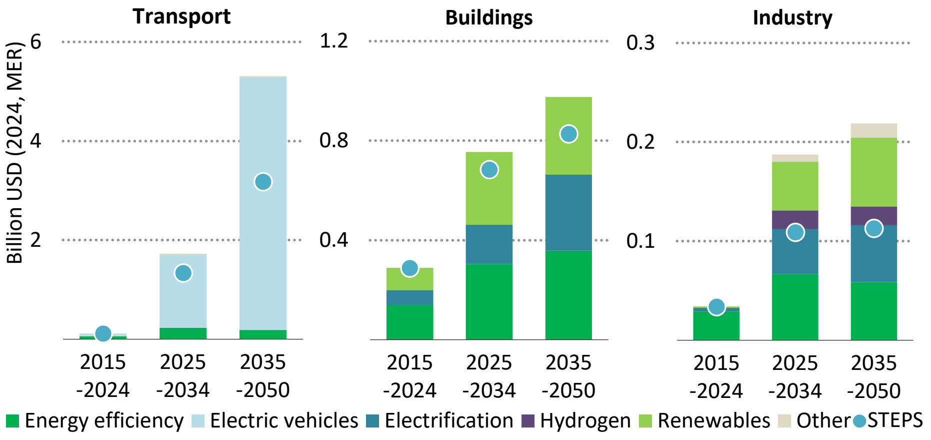
The decarbonisation target in the APS requires front-loading of investment and earlier mobilisation of financing than in the STEPS, in which investment increases at a slower pace to reach over USD 4 billion by 2035 for power. While the government's role in grid planning is vital, achieving the investment levels in the APS depends heavily on attracting private sector participation, especially for renewables generation.

For the last decade, energy investment in fuel supply in Chile has mainly been for natural gas supply. It increases gradually to 2035 in the APS, though investment in other fossil fuel supply declines. The lion's share of the investment in fuel supply in the coming decades is directed to low-emissions hydrogen and averages USD 1.5 billion per year from 2025 to 2035, and USD 2 billion per year from 2035 to 2050.

Investment in end-use sectors

Investment in energy end-use sectors has steadily increased over the past decade (Figure 3.6). Since 2011, investment grew at an annual average rate of 4%, most of which was in the transport sector, notably through the expansion of public transport and the electrification of the bus fleet. In the coming decade in the APS, energy efficiency and electrification are the dominant areas of investment with average annual investment in end-use sectors reaching more than USD 3 billion, which is seven-times the level in the period from 2015 to 2024, and 35% more than in the STEPS.

Figure 3.6 ▻ Average annual energy investment in end-use sectors by type in Chile in the APS and STEPS, 2015-2050



IEA. CC BY 4.0.

Investment rises across all end-use sectors, but transport leads the way thanks to the rapid uptake of EVs and electrification of public transportation

Notes: Energy efficiency investment is defined as the incremental spending on new energy-efficient equipment or the cost of refurbishment that reduces energy use (excluding labour). The intention is to capture additional spending compared to the reference technology and which leads to reduced energy consumption. Renewables for end-use applications include behind-the-meter technologies such as solar water heating and groundwater heat pumps for space conditioning. Other in industry includes rail, international bunkers and fossil fuels with carbon capture and storage. EVs in this figure include battery electric, plug-in hybrid electric and fuel cell vehicles.

Transport is the fastest growing end-use sector, with investment reaching an average USD 1.7 billion per year by 2035 in the APS, up from just USD 110 million today. Electrification of road transport is the main driver: annual investment in EVs triples between 2035 and 2050, as a result of Chile's National Electromobility Strategy which mandates that all new vehicle sales must be zero emissions by 2035. Investment requirements include spending for a 40-fold increase in the current number of charging stations which stand at 1 500. The STEPS sees a more moderate uptake of EVs and delivers about half the EV stock level achieved by 2050 in the APS. In the STEPS, investment requirements for EVs and charging stations are correspondingly lower at about 60% the level of the APS.

In the buildings sector, annual investment needs increase from around USD 300 million today to around USD 700 million in the STEPS and USD 770 million in the APS on average over the next decade. In both scenarios, the majority of investment supports energy efficiency improvements, including building retrofits and uptake of more efficient appliances, plus electrification of equipment such as for heat pumps, cooking and water heating. Investment in these areas reflects the rising level of adoption of low-emissions heating technologies in urban centres and stock turnover for appliances that are subject to minimum energy performance standards established in the National Energy Efficiency Plan (2022–2026). The key difference between the APS and STEPS is a slightly accelerated increase in investment in electrification and efficiency in the APS, averaging USD 450 million per year over the next decade, compared to USD 370 million per year in the STEPS.

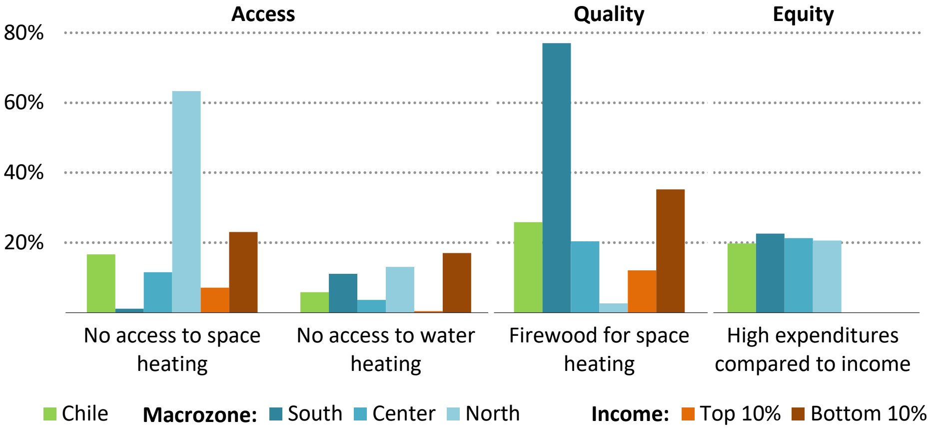
Energy-related investment in the industry sector sees a marked increase in the period to 2035 in both scenarios, albeit less than levels in the transport and buildings sectors. Investment in industry is directed to: improvements in material efficiency; electrification, including indirect electrification via onsite hydrogen production; and more use of renewables including biomass and geothermal. Total investment related to energy use in industry rises from annual average of USD 30 million in the 2015-2024 period to USD 100 million annual average over the next decade in the STEPS and almost USD 200 million in the APS. Differences in the rate of electrification, particularly of vehicles used in mining operations, account for a quarter of the variation between the two scenarios. The use of hydrogen in domestic industries also plays a role: although investment in hydrogen by domestic industry is comparatively low in the APS before 2035, the STEPS sees almost none at all.

3.4 Just transition

Ensuring access to affordable, reliable and high-quality energy services for all has long been a central objective of energy policy in Chile. Despite significant progress in some areas, notably achievement of almost universal access to electricity, several indicators across the three dimensions of energy poverty – access, quality and equity – show that there is more to be done.

Despite Chile's almost universal electricity access rate, gaps remain in access to essential energy services such as space and water heating (Figure 3.7). Around 15% of households report no access to space heating and more than 5% report no access to water heating (Ministerio de Desarollo Social y Familia, 2022). Regional disparities are stark: the lack of access is more prevalent in the Northern regions, but probably has a more severe impact in the colder Central and Southern regions. More than 75% of households in Southern regions currently report firewood being their primary fuel for space heating, causing severe air pollution and related health issues. In addition, more than 60% of households report having little to no insulation, driving up energy demand and reducing indoor comfort (Ministerio de Energía, 2025). These challenges disproportionately affect low-income households. Around one-in-five households face energy expenditure that is high in relation to their income. Low-income households are also more likely than others to lack basic space and water heating. Importantly, these figures do not capture the hidden side of energy poverty: households that limit essential energy services because they cannot afford them. For example, more than 15% of households were found to underspend compared to similarly sized households in comparable dwelling types, indicating unmet energy needs.

Figure 3.7 ▹ Access, quality and equity energy poverty indicators by share of households and by macrozone and income decile in Chile, in 2022



IEA. CC BY 4.0.

Energy poverty remains an issue,
indicated by significant disparities across regions and income levels

Note: The macrozones are categorised in the following regions: South (La Araucanía, Los Ríos, Los Lagos, Aysén, Magallanes), Center (Valparaíso, Región Metropolitana, O'Higgins, Maule, Ñuble, Biobío), North (Arica y Parinacota, Tarapacá, Antofagasta, Atacama, Coquimbo).

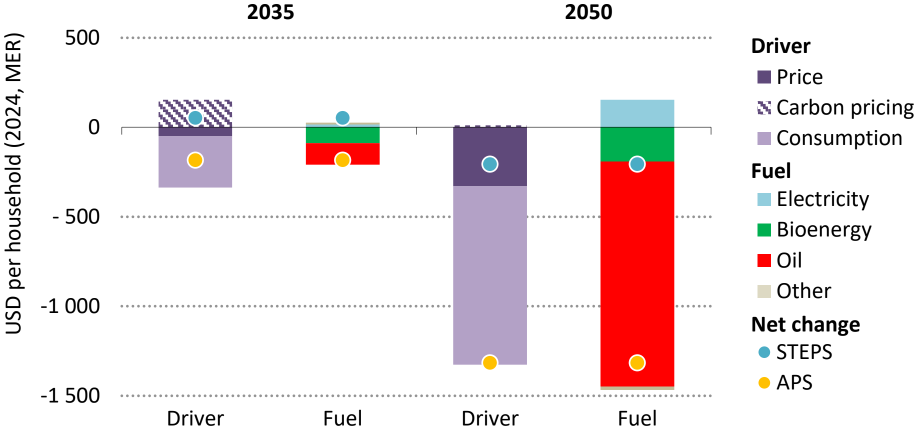
Sources: IEA analysis based on CASEN 2022 (Ministerio de Desarollo Social y Familia, 2022) and IX EPF (INE, 2022).

There are a number of reasons for the challenges. The upfront costs of clean energy technologies – such as insulation, heat pumps or EVs – often put them out of reach of low-income households. These groups have the highest need for efficiency improvements and the least access to affordable financing. As well, low-cost alternatives may be readily available, particularly for heating. Firewood, for example, is often cheap and abundant, making it an attractive option relative to electric heating and cooking, despite its negative health and environmental impacts. Other obstacles include a strong cultural reliance on firewood, a lack of awareness about its health impacts, and little access to information on existing subsidy measures or financing options.

3.4.1 Affordability

The higher levels of investment called for in the APS result in significant savings in average energy bills over time. As discussed, large-scale investment in building retrofits, EVs, heat pumps and more efficient appliances supports a shift towards cleaner fuels and higher efficiency in households and transport. As a result, average household energy bills gradually decline to 2035 as a limited increase in fuel prices in the short term is counterbalanced by large efficiency gains over time (Figure 3.8). By 2050, an increase in household electricity spending driven by the electrification of transport and heating is more than offset by a sharp fall in spending on fossil fuels and solid biomass, and average bills fall to a level more than 50% lower than today. In the STEPS, the decline in the average energy bills is more limited, largely due to the lower EV penetration.

Figure 3.8 ⊳ Change in average household energy bill by driver and fuel in Chile in the APS compared to 2024, in 2035 and 2050



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Energy bills fall as greater electrification and efficiency improvements sharply reduce spending on fossil fuel consumption while increasing electricity spending by much less

Notes: Household energy bills include spending on residential energy consumption and private transport fuels. Other includes natural gas, district heating and hydrogen.

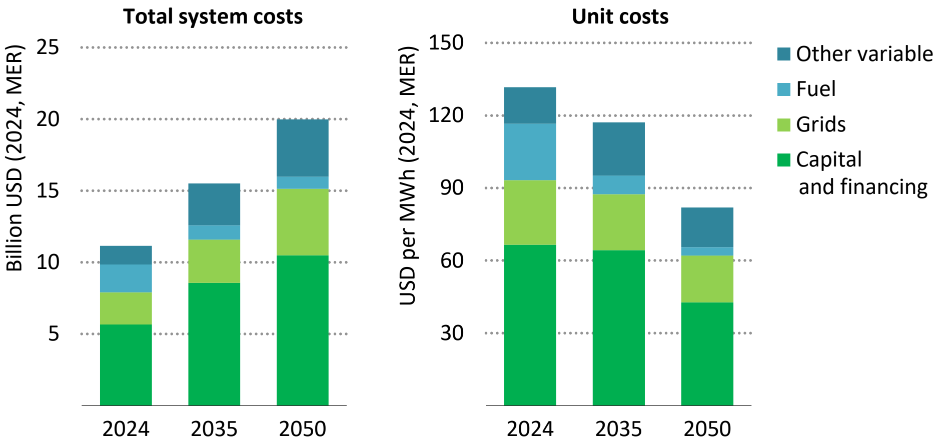
Sources: Energy prices are based on IEA Energy Data Centre and IEA analysis; CO_2 price trajectory based on (Ministerio de Energía, 2022).

Low-carbon, efficient technologies like electric cars and heat pumps are generally cost competitive, or close to cost competitive, over their lifetime compared with their fossil fuels counterparts, as discussed in Chapter 2. But their higher upfront costs are a big barrier for low-income consumers to adopt them. Targeted support policies can help them meet the upfront investment costs and thereafter benefit from cheaper and cleaner energy services.

Electricity costs

Electricity system costs cover all the operational and investment-related expenses associated with power generation across the power system, including the costs arising from fossil fuel inputs; power plant maintenance; capital expenditure on new and existing assets; services to maintain system stability; and transmission and distribution networks, including advanced transmission technologies and digitalisation for system management. In the analysis of electricity costs, it is assumed that all necessary investment has been made and that revenue streams have been secured to ensure sufficient rates of return on capital spending. While system costs are not a direct measure of wholesale or retail electricity prices, since they exclude market design and tariff structures, they serve as a useful indicator of the underlying costs to provide electricity and a proxy to consider how consumer prices may evolve in various scenarios. In many cases, average electricity prices to consumers are higher than the average system cost. The gap between electricity prices and total system costs primarily reflects additional profits (beyond a sufficient rate of return on capital spending), which can arise for several reasons, including market design or from legacy contractual arrangements.

Figure 3.9 ▷ Average annual total electricity system and unit costs per component in Chile in the APS, 2024, 2035 and 2050



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Net zero emissions path leads to lower system costs per unit of electricity relative to today's system, with fuel costs nearly 70% lower and system unit costs 15% lower by 2035

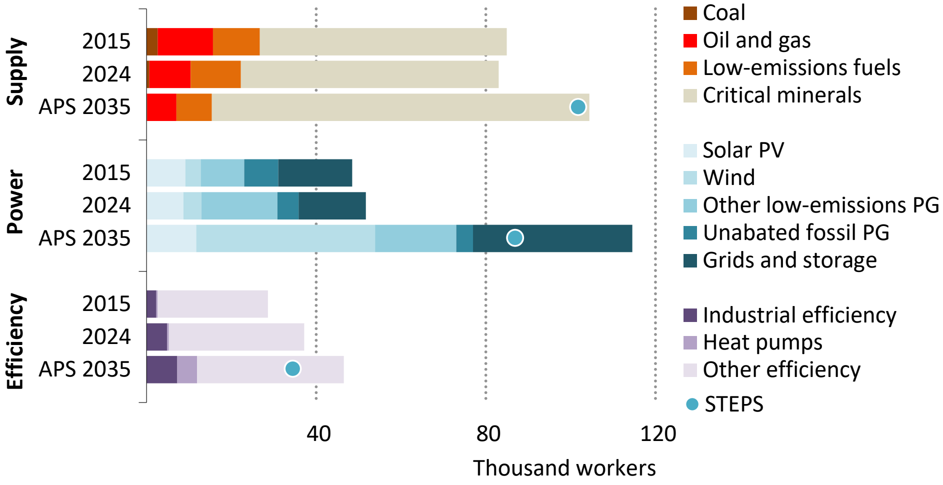
Notes: MWh = megawatt-hour. Other variable includes operation and maintenance costs and CO_2 costs.

In Chile, system costs per unit of electricity consumed decline over time in the APS, falling by 15% between 2024 and 2035 (Figure 3.9). The share of variable costs in total system costs drops significantly as coal-fired generation is phased out, and fixed costs, including capital and grids components, become more prominent as the generation mix shifts towards capital-intensive renewables. Fixed costs rise as electricity demand grows, but they decrease in absolute terms when measured per unit of electricity consumed. The system costs presented in our analysis are expressed in inflation-adjusted terms; they may evolve differently over time in nominal terms because of general price inflation.

3.4.2 Employment

The APS represents significant opportunities to expand employment in the energy sector in Chile. It provided about 170 000 jobs in 2024, equivalent to nearly 2% of the total labour force. In the APS, it is projected to expand by about 50% by 2035, adding around 90 000 new jobs (Figure 3.10). In the STEPS, growth is only half as high, mainly due to slower renewables deployment and grid expansion, along with fewer jobs in energy efficiency.

Figure 3.10 ▹ Energy employment in Chile by sector, 2015 and 2024, and in the APS and STEPS, 2035



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Employment growth in the power sector, critical minerals and energy efficiency significantly outweighs job losses in the fossil fuel sector in the APS

Notes: PG = power generation. Energy employment figures cover jobs in utilities, fossil fuel extraction and refining as reported in national statistics, as well as those in clean energy supply, critical minerals, energy efficiency, construction, and related service activities.

Most of the job growth is in the power sector with around 60 000 new jobs in the APS. With installed capacity expected to increase more than three-times by 2035, development of renewables becomes a major job creator, along with substantial requirements for the construction and operation of networks and energy storage systems. Improving energy efficiency in buildings and industries is labour-intensive and could generate a further 10 000 jobs.

Mining and processing of critical minerals, especially for lithium and copper, will continue to gain in significance and has the potential to create almost 30 000 new jobs, more than offsetting the projected job losses in the fossil fuel sector (see Chapter 4). Moreover, many skills from fossil fuel activities, such as the ability to operate heavy machinery and implement safety protocols, are transferable to critical minerals extraction and processing. The low-hydrogen sector is projected to be another generator of new jobs, notably in construction.

Yet, challenges are ahead. Jobs in the power sector and in deploying energy efficiency measures can tend to be high-skilled positions. This is a positive aspect of the transition, but the speed of change poses challenges, and insufficient pools of skilled labour could become a bottleneck. National projections suggest that potential skilled labour supply gaps could emerge by 2035, particularly for engineers and mid-skilled technicians (Ministerio de Energía, 2024). Attracting more young people to technical and vocational studies relevant to energy is an important area for action. Such efforts should be designed to incorporate and train women, as currently women represent only about 20% of the energy workforce in Chile.

Geographic mismatch between likely project locations and the available labour pool will need attention. Large-scale critical mineral mining and hydrogen projects will be located in remote areas of northern and southern of Chile, whereas most of the workforce is concentrated around Santiago and other urban areas. Proactive policies such local hiring initiatives, public infrastructure development and rotational shift schemes could help mitigate the difficulties. Jobs in the power sector and energy efficiency are more likely to be created in densely populated areas, although some large renewables projects and transmission lines may require work in remote regions.

Box 3.1 ▷ Just Energy Transition Strategy in Chile

The phase-out of coal in Chile is well underway. The last mine was closed in 2020. By the end of 2025, 65% of its coal plants will have been retired, with the remaining plants following by 2040. The phase-out policy is underpinned by a comprehensive Just Energy Transition Strategy (JETS) put forth in 2021 and updated in 2025. The JETS aims to minimise the socioeconomic impact on communities that are home to coal power plants and coal ports.

The JETS framework, which is reflected in the 2024 Decarbonisation Plan, is aligned with global best practices for managing coal transitions. It is based on four pillars:

- Supporting affected workers and communities through employment programmes, retraining and social protection.
- Stimulating economic diversification and investment in clean energy industries, including electrolytic hydrogen and circular economy initiatives.

- Repurposing coal infrastructure and improving environmental quality through regulatory reform and territorial planning.
- Establishing inclusive governance mechanisms to co-ordinate action across ministries, local authorities, companies and civil society.

Chile has developed local action plans as the primary vehicle to deliver just transition outcomes in coal-dependent regions. They aim to ensure that the phasing-out of coal not only avoids harm to affected communities but actively supports their long-term revitalisation by addressing the specific social, economic and environmental challenges of each affected area. Their objectives include supporting displaced workers through retraining and job placement, promoting new industries and investment, repurposing local coal infrastructure and improving environmental quality. In the province of Tocopilla, for example, which saw the closure of four coal-fired power units from 2019 to 2022, local action plans involve 58 stakeholders and specify 115 measures related to energy, environment, health and economic development. Measures range from support for education and job retraining to infrastructure improvements and environmental remediation, and the plans seek to ensure inclusive participation through engagement with unions and local citizen organisations.

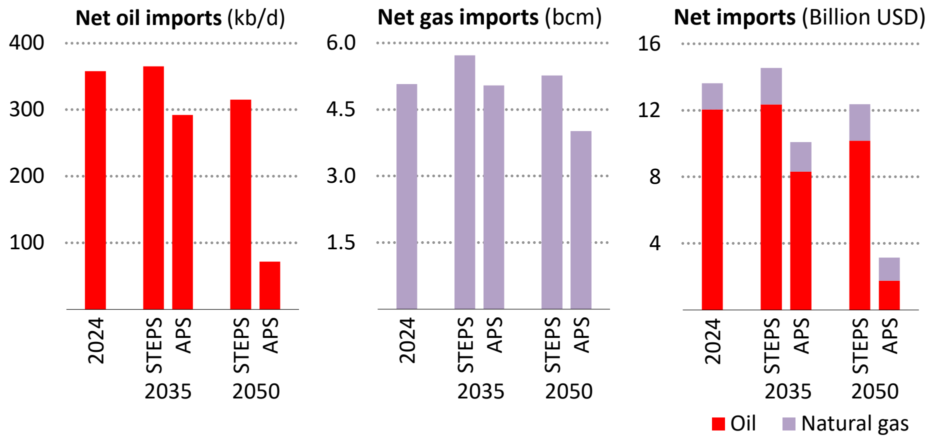
The individual local action plans are co-ordinated nationally through the Interministerial Committee for the Just Socioecological Transition (ICJST), which includes the environment, energy, labour, economy and other ministries. The ICJST provides strategic guidance and ensures that local action plans are aligned with national climate and development goals. A technical secretariat, led by the Ministry of the Environment, is responsible for articulating, implementing and monitoring the plans, while local committees participate in their design and monitor their execution. While the JETS provides a robust framework, success ultimately depends on mobilising public and private resources to implement action plans. Securing sufficient funding is a critical challenge for the strategy’s long-term viability and legitimacy.

3.5 Energy security

3.5.1 Moving away from import dependence

Chile's shift away from fossil fuel dependence, which is largely imported, represents a fundamental paradigm that leverages the country's exceptional renewable energy resources. In the APS, this shift brings about a fall of 72% in Chile’s net energy imports between 2024 and 2050. Although this change takes place over a quarter of a century, it still represents a dramatic change, reducing the amount that Chile spends on natural gas and oil imports by almost 80% from around USD 14 billion today to USD 3 billion by 2050, and boosting its energy security at the same time (Figure 3.11). As a result, emissions drop dramatically.

Figure 3.11 ⊳ Oil and natural gas imports and net import bills in Chile in the STEPS and APS, 2024-2050



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Electrification and decarbonisation help Chile to reduce its dependence on oil imports in the APS

Note: kb/d = thousand barrels per day; bcm = billion cubic metres.

In the STEPS, enacted policies are insufficient to reduce fossil fuel import bills over the next decade, resulting in import bills rising by around 7% by 2035 compared with 2024 levels. The APS offers a pathway to lower fossil fuel import bills, but achieving this requires substantial investment in decarbonising electricity and expanding electrification.

This shift is made possible by, and depends on: deployment of renewables in the power sector and elsewhere; electrification of road transport and many other end-uses; expansion and reinforcement of electricity grids; and major efficiency gains across all sectors. It also reflects the National Green Hydrogen Strategy, which is currently being revised, but includes large-scale electrolytic ammonia projects to serve both domestic demand and export markets, reducing dependence on imported products while creating new revenue streams. In the APS, these projects play a key role in scaling up low-emissions hydrogen production and positioning Chile as a leading global exporter of hydrogen-related products.

3.5.2 Electricity security

Electricity demand and supply must be balanced at all times, requiring system operators to secure adequate resources to meet peak demand. Generation capacity, transmission infrastructure, storage technologies and demand response all play critical roles. Yet ensuring resource adequacy is becoming increasingly complex as electrification, climate change and shifting consumption patterns reshape demand profiles. In Chile, the increasing adoption of

EVs raises daily peaks in the APS, while seasonal winter and summer peaks are set to grow as a result of the increasing use of electric space heating and air conditioners.

While peak electricity demand is a critical metric for assessing resource adequacy, the main challenge in systems with high shares of variable renewables lies in meeting demand when low renewable output coincides with periods of high consumption, known as peak net load.[1] At these times, the supply mix differs markedly from the annual average. Lower output from wind and solar PV has to be offset by operating dispatchable plants, such as those fuelled by natural gas, coal or hydropower; making use of storage; and deploying demand-response measures.

Traditionally, adequacy planning has focused on periods of low renewables output, but hours with very high shares of variable renewables also pose operational challenges. For instance, system operators must maintain sufficient inertia to slow frequency deviations after sudden imbalances, giving control and protection systems time to respond and preserve grid stability. This can involve keeping a minimum level of synchronous generation online from sources such as thermal or hydropower plants. Additional options include synthetic inertia from battery storage, variable renewables equipped with grid-forming inverters, and advanced grid technologies such as flexible alternating current transmission systems – including enhanced static synchronous compensators (STATCOMs) or synchronous condensers – deployed at strategic points in the grid. The grid operator in Chile conducted a synchronous condenser tender in 2024, and further tenders for infrastructure aimed at strengthening the grid are planned.

As well as being able to meet peak demand, electricity systems must be flexible enough to manage variability in demand and supply, ensuring instantaneous stability and hourly balance throughout the year. As variable renewables deployment and electrification accelerate, flexibility needs are increasing in both scale and complexity.

Short-term flexibility addresses hour-to-hour variations, which are increasingly being shaped by pronounced daily cycle of solar PV. This leads to steep residual load changes: a sharp decline after the morning peak as solar PV ramps up, followed by a rapid rise in the afternoon as solar PV output falls and demand peaks in the evening. In the APS, short-term flexibility needs triple by 2035 compared to 2024, reaching 48% of average demand, or 7 gigawatts (GW): this increase is double the average growth of the system.

Seasonal flexibility, by contrast, deals with longer term imbalances – weekly or monthly – driven by temperature-sensitive demand and weather-dependent generation. Seasonal flexibility needs can vary significantly from one year to another because of differences in temperature and weather patterns. In the APS, seasonal flexibility needs also triple on average between 2024 and 2035 – doubling compared to average electricity demand growth – and could rise nearly four-times higher than in 2024 under unfavourable weather conditions (Figure 3.12).

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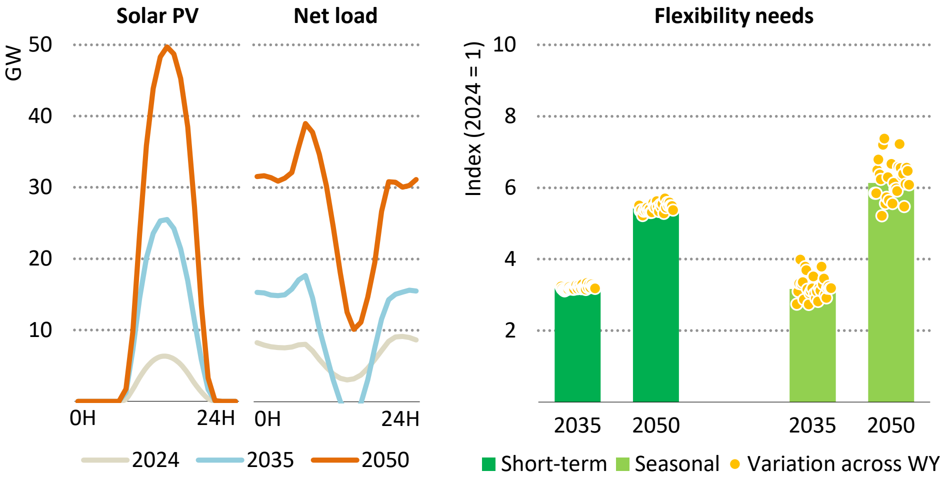
[1] Net load is defined as the total load minus the contribution of variable renewables.

Figure 3.12 ▻ Average daily variation of the net load and annual power system flexibility needs in Chile in the APS, 2024, 2035 and 2050



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Both short-term and seasonal flexibility needs triple to 2035; seasonal flexibility needs can vary significantly from year to year because of weather variations

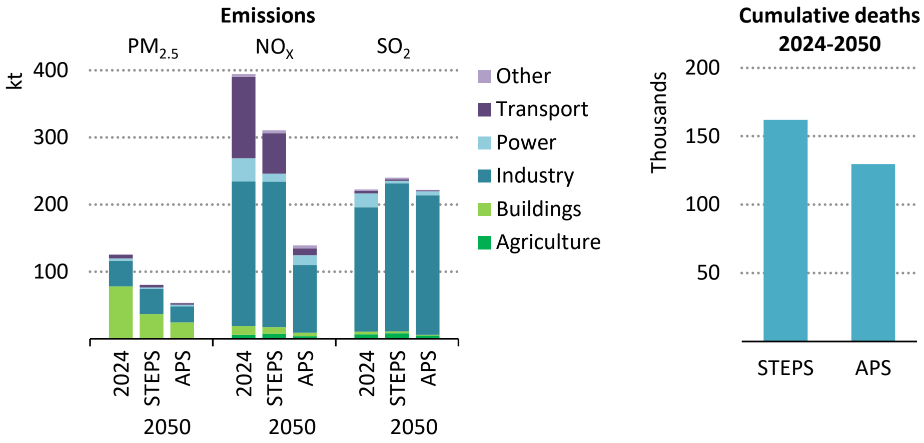
Note: GW = gigawatt; WY = weather years.

Currently, both seasonal and short-term flexibility needs in the power system in Chile are largely met by thermal and hydropower plants. In the APS, the share of variable renewables rises, coal-fired power plants are gradually phased out, and new, potentially flexible loads, such as EVs and heat pumps, are connected to the grid. With less thermal capacity to draw on and more potentially flexible demand, battery storage – which accounts for a third of installed dispatchable capacity in Chile in 2035 – and demand response are projected to cover an increasing share of short-term balancing needs. Over time, the remaining thermal plants increasingly shift towards providing seasonal flexibility and secure capacity. Hydropower is expected to remain a key source of both seasonal and short-term flexibility.

3.6 Air pollution

Air pollution remains one of Chile's most pressing environmental and public health challenges, with national emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X) and fine particulate matter ($PM_{2.5}$) requiring significant reductions to meet climate and health targets. In the STEPS, Chile achieves limited progress by 2050. NO_X falls by around 20% from current levels and $PM_{2.5}$ by around 35%. While SO_2 emissions from the power sector drop by around 80% as coal plants retire and renewables expand, total SO_2 emissions increase by around 8% as a result of increased mining and industrial activity (Figure 3.13).

Figure 3.13 ▷ **Air pollution by pollutant and source, and number of premature deaths by scenario in Chile, 2024-2050**



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Increased ambition to reduce major air pollutants in the APS could avoid around 32 000 premature deaths between 2024 and 2050, compared to the STEPS.

Note: NO_X = nitrogen oxides; $PM_{2.5}$ = particulate matter with a diameter of 2.5 micrometres (µm) or less; SO_2 = sulphur dioxide; kt = thousand tonnes.

Source: IEA analysis based on IIASA (Institute of Applied Systems Analysis) modelling.

In the APS, there are much larger reductions in the levels of each of these pollutants. By 2050, NO_X emissions fall almost 65% below 2024 levels, and $PM_{2.5}$ reductions fall by almost 60%. SO_2 emissions fall sharply in the power sector, but industry SO_2 emissions remain a challenge, not least because of the nature of certain metallurgical processes. Many of these processes, notably the roasting of sulphide ores in copper smelters, produce large SO_2 streams that require dedicated capture or treatment systems.

Santiago, home to about 40% of the population of Chile, is widely acknowledged as being among Latin America's most polluted cities. It stands to benefit substantially from reductions in the level of $PM_{2.5}$, of which concentrations in the STEPS are projected to fall by around 12% by 2050 from around 29 microgrammes per cubic metre (µg/m³) in 2020. The projected reduction in the APS is three-times larger at 36%, though Santiago would still remain well above the World Health Organization air quality guidelines of 5 µg/m³ (WHO, 2021). Road transport is one of the leading causes of $PM_{2.5}$ emissions in many large cities, and Santiago is no different, although emissions from the industry and buildings sectors also contribute. Emissions originating outside the city also play a critical role: IIASA modelling shows that around half of Santiago's $PM_{2.5}$ burden is attributable to livestock, fertiliser use and industry beyond the metropolitan area.

In southern Chile, the combustion of wood in households for space heating and cooking is a major contributor to $PM_{2.5}$ emissions and leads to particularly high concentrations in the winter. There are various options to decrease these emissions: using fuels with a low moisture content such as dry firewood and biomass pellets cuts emissions, as does the use of efficient, modern stoves which control airflow and combustion; improving the insulation of homes decreases the amount of heating needed; and switching from biomass to electric heating avoids the combustion of wood entirely. Thanks to these measures, the use of solid biomass in buildings for space heating and other purposes drops by two-thirds by 2050 in the APS.

The human toll of air pollution is severe in Chile: currently around 5 000 premature deaths occur every year, which means that more than twice as many people die prematurely each year as a result of air pollution than are killed in road traffic accidents. Between 2024 and 2050, cumulative premature deaths from ambient air pollution are projected to reach around 160 000 in the STEPS. The APS pathway avoids more than 32 000 of these deaths by achieving faster and deeper cuts in emissions from transport, industry and residential heating.

In the APS, the economic benefits to Chile of improved air quality are substantial and multifaceted. Recent estimates indicate that air pollution currently costs the country USD 5 billion annually, equivalent to 1.6% of national GDP. The economic burden is particularly severe in southern Chile (La Araucanía, Los Ríos and Los Lagos), where it is estimated that air pollution costs represent 4% of regional GDP (Universidad San Sebastián, 2024). Reduced exposure to ambient $PM_{2.5}$ and other pollutants lowers healthcare expenditure by decreasing the incidence of cardiopulmonary illnesses, asthma and chronic bronchitis. Lessening the number of illnesses translates into reduced direct medical costs and lower spending on long-term care and pharmaceuticals.

Avoiding premature deaths also has economic value, quantified as the "value of a statistical life", which places the benefit of each life saved from cardiopulmonary disease in Chile at approximately USD 2 million (Barrientos, 2024). On this basis, the 32 000 lives preserved by 2050 under the APS represent social welfare gains of around USD 66 billion over the period, which is equivalent to 20% of current annual GDP. These health-driven economic gains offset a significant portion of the costs of investment in the clean energy transition, underscoring the strong return on investment from air pollution mitigation.

Emerging themes

Opportunities and challenges in a changing climate

SUMMARY

- Chile has the potential to become a leader in the supply of low-emissions hydrogen and consolidate its position as a leading producer of critical minerals for global clean energy technology manufacturing. Its development would increase demand for electricity and require enhanced power system resilience measures.
- Chile's excellent renewable resources could enable cost-competitive production of low-emissions hydrogen. However, financing costs are a major factor, making up around 45% of the average costs to produce hydrogen. By 2050, hydrogen-based fuels represent a US dollars (USD) 13 billion export market for Chile in the Announced Pledges Scenario (APS), underpinned by the potential to utilise biogenic CO_2 waste streams from its pulp and paper industry for methanol and synthetic fuel production.
- Chile's domestic use of hydrogen quadruples by 2050 in the APS, with further growth potential from onshoring ammonia production, which would deepen value creation. Chile could make use of its industrial base to create early demand for low-emissions hydrogen by producing ammonia, urea and other nitrogen-based fertilisers. This would reduce the trade deficit by lowering reliance on imports of explosives for the mining industry and fertilisers for agriculture. By 2035, electrolytically produced ammonia in Chile is competitive with gas technologies in the APS, and increased domestic production could reduce exposure to volatile international spot markets
- Chile is the world's largest producer of copper and the third-largest producer of lithium. In the APS, global copper demand rises 50% by 2050 from current levels, and lithium demand increases sevenfold by 2050. Chile's critical minerals revenue reaches USD 100 billion by 2040, close to one-fifth of the global total. The current project pipeline for copper suggests a decline in Chile's production after 2035, and lithium output would stabilise without new projects.
- There are opportunities for Chile to support technological innovation to enhance its role in the critical minerals supply chain. It is strengthening its policy and regulatory framework to ensure that mineral extraction is carried out in full conformity with national sustainability goals and international standards.
- Chile's power system has proven resilient to seismic risks, but climate-related threats are intensifying. Rising temperatures and a long-term decline in rainfall put further pressure on grid reliability and planning. The most severe rainfall impacts are in the southern and central region, where hydropower facilities are concentrated. Risks from wildfires is also rising. Chile's geography adds complexity, requiring region-specific adaptation strategies. Chile has developed a range of resilience assessment tools, but they are not yet fully integrated into long-term energy policy planning.

4.1 Introduction

While global demand for low-emissions hydrogen is limited today, it increases rapidly in the Announced Pledges Scenario (APS) to reach 200 million tonnes of hydrogen (Mt H_2) in 2050, with Chile accounting for 2% of global production and becoming one of the largest exporters in the world. Demand in the Stated Policies Scenario (STEPS) is only a fifth of the level in the APS in 2050, and is limited to countries that have policy frameworks that encourage the use of low-emissions hydrogen, or that have specific mandates for low-emissions fuels for the shipping and aviation sectors. In the Net Zero Emissions by 2050 (NZE) Scenario, on the other hand, global demand for low-emissions hydrogen is twice the level in the APS by 2050.

Chile is a major producer of copper and lithium. Demand for both increases in all IEA scenarios in the period to 2050, when annual global demand for copper reaches almost 40 million tonnes (Mt) in the APS, up from 27 Mt today. Global copper demand is 6% lower in the STEPS, and 4% higher in the NZE Scenario. Annual global demand for lithium reaches 1.5 Mt in 2050, up from 0.2 Mt in 2024: it is roughly 25% lower in the STEPS and 20% higher in the NZE Scenario. As demand rises, Chile, together with other countries in Latin America, could exploit regional synergies to move up the ladder in the critical mineral supply chains and to produce high value products.

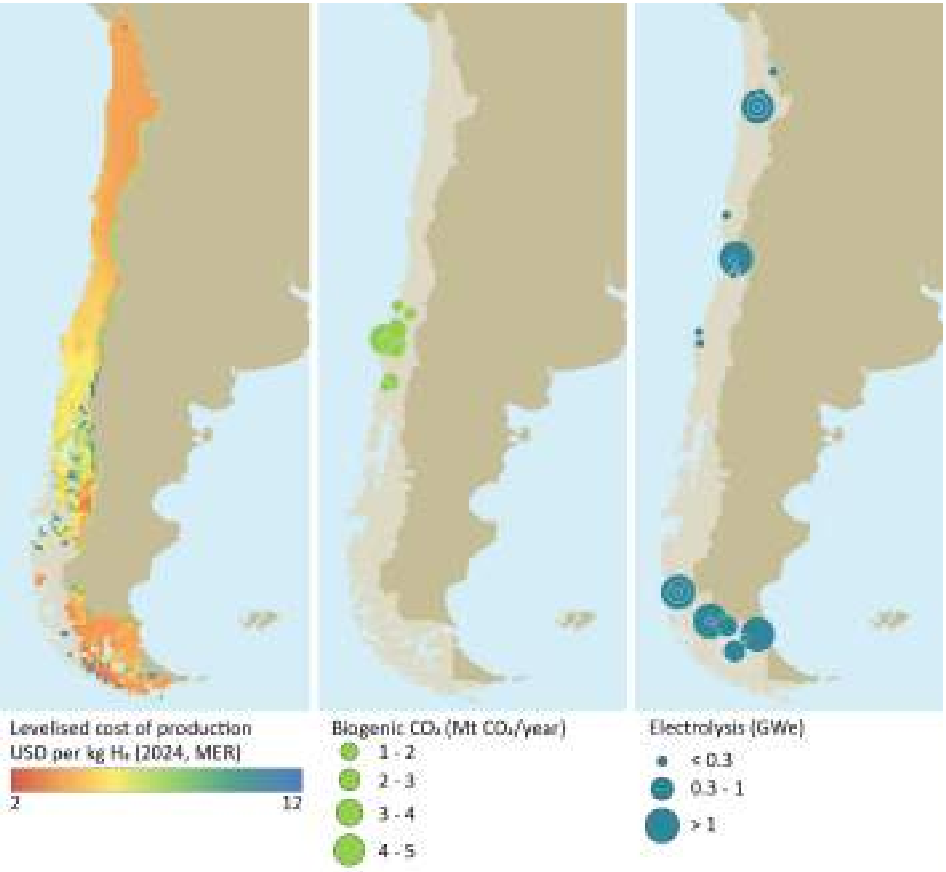
Chile could position itself as a key producer of low-emissions hydrogen and of the critical minerals needed for clean energy technology manufacturing. This depends on it being able to meet the extra demand for electricity and on measures to ensure power system resilience. This chapter explores the issues that this raises for Chile.

4.2 Low-emissions hydrogen

In 2024, Chile produced nearly 200 kilotonnes (kt) of hydrogen, or around 0.2% of global output. This was mainly used for methanol production and, to a lesser extent, for refining. Steam methane reforming of natural gas supplied about 85% of total hydrogen output, accounting for over 10% of natural gas demand in Chile.

In recent years, Chile has experienced a rapid surge in the number of announced low-emissions hydrogen projects, driven by its outstanding renewable energy potential. If all announced projects are realised, annual electrolytic hydrogen production in Chile could exceed 1.3 Mt H_2 by 2030, representing around 3.5% of global announced hydrogen output (37.7 Mt H_2) and nearly 5% of announced electrolysis-based production (Figure 4.1). Chile holds the second-largest project pipeline in Latin America after Brazil, and the tenth-largest worldwide. However, these projects remain a long way from maturity: operational facilities in Chile are still in the single-digit megawatt range, and only 0.01% of the announced volume by 2030 has at least reached a final investment decision, compared to more than 11% globally. This uncertainty about the deployment pipeline limits hydrogen uptake in the STEPS, but the APS projects significant growth in line with Chile's hydrogen ambitions and global climate commitments. Its total low-emissions hydrogen demand in 2035, including domestic uses and export, is more than five-times larger than in the STEPS. In the APS, most hydrogen production is from off-grid projects, allowing developers to draw directly from Chile’s excellent renewable resources without putting extra strain on the electricity system.

Figure 4.1 ▷ Levelised cost of off-grid electrolytic hydrogen production, available biogenic CO_2 resources and announced electrolytic hydrogen projects with announced operational date by 2030



Northern and southern Chile offer some of the world’s lowest hydrogen production costs and have the second largest pipeline of announced projects in Latin America

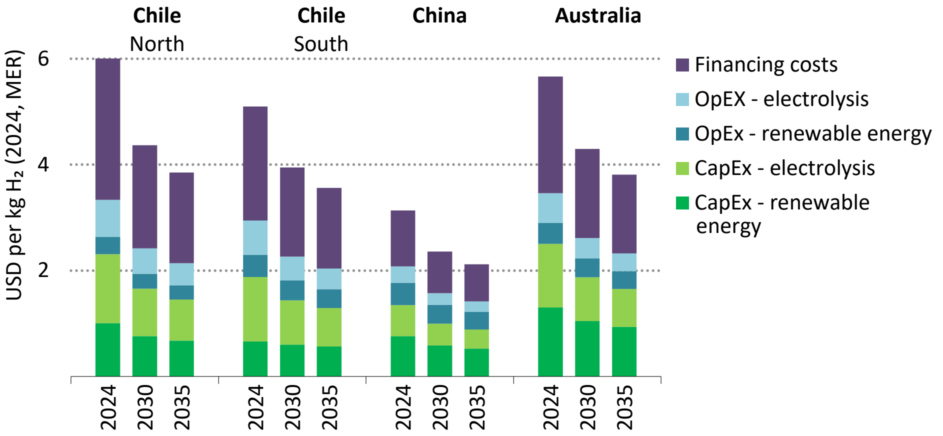
Notes: GWe = gigawatt electric; Mt = million tonnes; kg H_2 = kilogrammes of hydrogen; USD = US dollar. Hydrogen production is based on the lowest cost configuration among solar photovoltaics (PV), onshore wind and battery systems. Technology assumptions follow the IEA Stated Policies Scenario for 2030. Biogenic CO_2 resources refer to CO_2 streams of biogenic origin, i.e. by-products, where emissions exceeding 100 kilotonnes per year CO_2 within a radius of 30 kilometres can be aggregated to achieve economies of scale for potential capture and combination with hydrogen to produce synthetic fuels or urea.

Sources: IEA analysis based on data from Jülich Systems Analysis at Forschungszentrum Jülich using the ETHOS model suite Jülich Forschungszentrum (2025) and IEA Hydrogen Production Projects and Infrastructure Database (IEA, 2025a,b).

4.2.1 Competitive advantages to develop low-emissions hydrogen production in Chile

Taking account of stated policies globally, the cost of producing electrolytic hydrogen could fall to around US dollars (USD) 2-4 per kg H_2 in several parts of the world by 2030. This would bring some regions close to cost parity with hydrogen produced from fossil fuels: the cost of hydrogen production from unabated natural gas, i.e. without carbon capture, utilisation and storage, ranged from USD 0.8 to 4.4/kg H_2 in 2024, with costs at the higher end observed in natural gas importing countries.

Figure 4.2 ▹ **Indicative levelised cost of hydrogen production from electrolysis with off-grid renewable energy in good locations, 2024-2035**



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In Chile, high financing and electrolyser costs dominate production costs; lowering CapEx cuts investment and financing expenses, significantly reducing overall costs

Notes: CapEx = capital expenditure; OpEx = operational expenditure; MER = market exchange rate. Renewable energy includes stationary batteries. Hydrogen production is based on the lowest cost configuration among solar PV, onshore wind and battery systems in optimal locations in the country/region shown. In 2024, solar PV CapEx is USD 600-920 per kilowatt (kW); onshore wind CapEx is USD 1 050-1 580/kW; battery CapEx is USD 175 per kilowatt-hour (kWh); and electrolyser CapEx is USD 900-2 300 per kilowatt electric $(kW_e)_y$ with an efficiency of 58-63%. In 2030, solar PV CapEx is USD 400-650/kW; onshore wind CapEx is USD 940-1 550/kW; battery CapEx is USD 175/kWh; and electrolyser CapEx is USD 670-1 610/kW_e with an efficiency of 62-64%. The electrolyser stack is replaced after 50 000 hours of operation. The cost of capital is assumed to be between 5.8-8.4%, and for Chile 8.4% is assumed. Solar PV capacity factors are calculated assuming utility-scale solar PV facilities with polycrystalline silicon modules (best available technology [BAT] in 2030) and single-axis tracking at site adapted tilt angle for fixed-tilt systems. Onshore wind capacity factors are calculated based on a wind turbine with a rotor diameter of 182 metres (m), with a hub height of 111-189 m and a reference capacity of 6.5 megawatts (MW), both site-adapted (BAT in 2030). Offshore wind capacity factors are calculated based on a 222 m rotor diameter wind turbine with a hub height of 100-170 m and a capacity of 10-17 MW, both site-adapted (BAT in 2030). Solar PV and wind capacity factors are calculated based on average capacity factors over the 2000-2019 period. Water costs are not included.

Source: IEA analysis based on capacity factors from Jülich Systems Analysis at Forschungszentrum Jülich using the ETHOS model suite Jülich Forschungszentrum (2025).

By 2030, China is expected to produce electrolytic hydrogen for around USD 2/kg H_2, and to be the lowest cost producer in the world. In others such as Australia, Middle East, Chile and other Latin American countries, production cost could fall to around USD 4/kg H_2 (Figure 4.2).[1] Variations in these costs across among these are relatively modest, meaning that overall competitiveness will probably depend on project-specific factors such as the cost of capital, local engineering, procurement and construction (EPC) costs, and financing conditions, rather than on differences in renewable resource potential.

Low hydrogen production costs in China reflect its ability to obtain physical equipment and financial capital at a lower cost than competitors. Although Chile's superior renewable resources enable a given quantity of hydrogen to be produced with less equipment than in China, this advantage alone is insufficient to bring the cost of hydrogen production down to the level of production in China. Electrolyser costs are more than two-times higher in Chile than in China[2], plus the costs of financing capital-intensive production contributes to around 45% of the levelised cost of hydrogen in Chile, compared to less than 35% in China, where access to low-cost financing is enabled by state-owned banks.

A continuing decline in renewable energy costs, along with a reduction in electrolyser costs driven by increased deployment, improved system integration and technological innovation, is projected to drive down hydrogen production costs worldwide. As this occurs, there are three key ways to improve Chile's competitiveness:

- **Reduce the cost of capital**. International experience demonstrates that support from governments and public institutions can reduce financing costs and foster private investment. Chile can also help lower the cost of capital for projects by mitigating regulatory uncertainty, streamlining permitting, developing enabling infrastructure such as power grids or ports, providing guarantees and seeking collaboration with development finance institutions such as multilateral banks. Developers can mitigate project-specific risks by securing long-term offtake agreements and requiring performance guarantees or similar warranties from original equipment manufacturers and suppliers.
- **Access more affordable equipment.** Chile's limited role in global manufacturing means it cannot by itself drive capital expenditure (CapEx) reductions. However, it can foster

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[1] While some grid-connected electricity could complement dedicated renewables in otherwise off-grid projects to increase electrolyser utilisation, the economic viability of such hybrid configurations will depend heavily on electricity tariffs, which vary by country and region. These tariffs can also change over time for various regulatory and system planning reasons, and unlike technology costs or learning rates, cannot be anticipated. As this economic assessment focuses on resource potential and on cost elements that can be reasonably projected, it only examines off-grid configurations.

[2] Electrolysers in China are considerably cheaper due to strong economies of scale, a mature manufacturing supply chain, and extensive experience with large construction projects that reduce balance-of-plant and EPC costs, which account for around 80% of total CapEx. These advantages are reinforced by supportive government policies that have driven domestic demand, as well as by companies leveraging financial resources and expertise from the renewable sector. However, the cost of Chinese electrolyser stacks (20% of CapEx) is also lower due to reduced performance and efficiency levels, as well as limited compliance with international standards.

international partnerships and deeper integration into global supply chains to facilitate technology transfer and economies of scale. It can also work to minimise project costs, as around 50% of project investment costs are EPC costs that depend to a larger extent on local conditions.

- **Reduce operating and maintenance costs and maximise power generation efficiency.** This means optimising maintenance and its schedules. In the case of solar PV, it also means minimising the accumulation of dust, pollen, salt and other particles on panel surfaces, which can significantly reduce power output, particularly in Chile's arid regions. The Antofagasta region is already addressing this challenge by assessing the impact of soiling and by developing mitigation strategies for subsequent hydrogen production.

Building a new industry such as low-emissions hydrogen takes time, and success is much more likely if there is support from government and public agencies on key issues, Priorities include reducing early-stage project risk through measures such as support for development expenditures (DevEx)[3]**,** and developing shared port infrastructure so as to lower costs and facilitate the development of clusters of projects, as in the ENAP-EDF partnership to use existing port facilities in the Magellan Strait for ammonia exports (Soventix Chile, 2024).

Public policy can also strengthen local value creation by supporting domestic manufacturing and supply chain integration, as illustrated by CORFO's[4] funding for the establishment of electrolyser assembly facilities, and by ensuring that adequate desalination capacity is available for projects in arid regions (see Chapter 2, Box 2.3). Although water costs could represent up to around 3% of hydrogen production costs, large projects will require sizeable desalination plants with long lead times and significant upfront investment, and advance planning can ensure that they improve local water access as well as supporting hydrogen-related projects.

4.2.2 Low-emissions hydrogen-based fuels in Chile could unlock a large export market

The pace at which global markets for low-emissions hydrogen and its derivatives will develop remains uncertain. If trade in low-emissions fuels scales up, diversification of supply will be critical to limit concentration risks and enhance market resilience. Chile could play an important role in such a diversified supply landscape. Hydrogen looks set to play an important role in the decarbonisation of shipping and aviation around the world, and there is an opportunity for Chile to contribute to the decarbonisation of international shipping by supplying low-emissions bunker fuels to international vessels and supporting their use in vessels that call at its ports. The potential scope for this is underlined by the creation of a consortium including BHP, Berge Bulk, Engie and Mejillones Ammonia Energy that aims to

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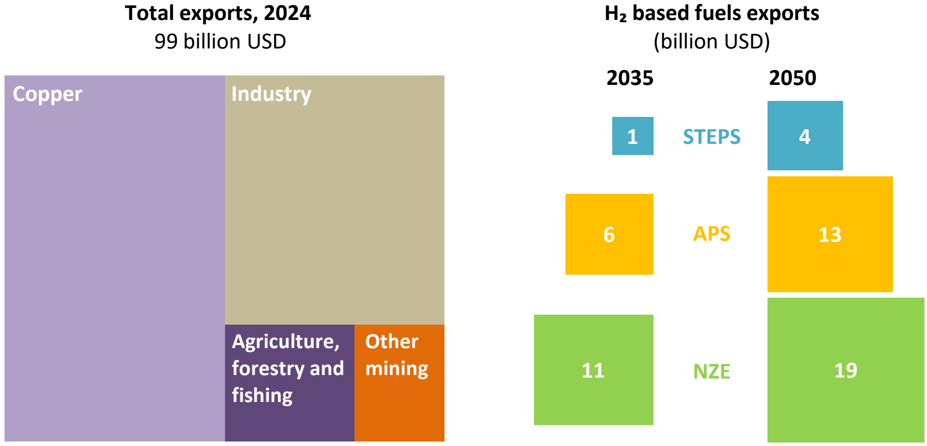
[3] DevEx represents the cost associated with developing a project up to the point of financial close or construction.

[4] CORFO is the Spanish acronym of Chile´s Production Development Corporation, a governmental organisation to promote regional economic growth.

conduct trials of on-board ammonia cracking for copper ore shipping in dry bulk carriers. Similarly, its biogenic CO_2 resources and sustainable aviation fuel production ambitions mean it could play a role in the decarbonisation of the aviation sector (see Chapter 2, Box 2.2).

In the APS, the global market for low-emissions hydrogen and its derivatives reaches nearly 200 Mt hydrogen equivalent (H_2-eq)[5] by 2050, with an estimated value of almost USD 800 billion. Inter-regional trade is around 55 Mt H_2-eq by 2050, and is worth about USD 200 billion, or roughly two-thirds of the value of today's global natural gas trade (around USD 300 billion). Low-emissions hydrogen-based fuels such as ammonia and methanol account for more than half of the energy consumed by the shipping sector in 2050, and for less than 10% in the aviation sector. In the STEPS, the global market for low-emissions hydrogen remains modest, reaching around 40 Mt H_2-eq by 2050, with an estimated value of USD 180 billion and 20 Mt H_2-eq of trade. In the more ambitious NZE Scenario, both demand and trade expand substantially: the global market expands to almost 400 Mt H_2-eq, exceeding USD 1.3 trillion, while inter-regional trade is more than 30% higher than in the APS, reaching almost 75 Mt H_2-eq and USD 300 billion.

Figure 4.3 ▻ **Market size of Chile's total exports in 2024 and exports of low-emissions hydrogen-based fuels, 2035-2050**



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Exports of low-emissions hydrogen-based fuels in the APS reach USD 13 billion by 2050, which is equivalent to almost 15% of its total exports today

Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario. USD are expressed in 2024 values using MER.

Source: 2024 total free on board exports from Banco Central de Chile (2025).

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[5] H_2-eq (hydrogen equivalent) refers to the amount of hydrogen, in mass units, required to produce ammonia, methanol or synthetic kerosene, allowing for direct comparison across different hydrogen-based fuels and carriers.

Chile accounts for more than 6% of inter-regional low-emissions hydrogen trade in the APS by 2050 (excluding intra-regional exchanges within the IEA's Global Energy and Climate Model [GEC-M] regions). Its exports of more than 3.5 Mt H_2-eq of low-emissions hydrogen and hydrogen-based fuels in the APS could generate about USD 13 billion of revenue by 2050 (Figure 4.3). This is comparable to almost 15% of the value of its total exports in 2024. In the STEPS, the global demand for low-emissions hydrogen is lower, and so is Chile´s export potential. In the NZE Scenario, rising global demand for low-emissions hydrogen further increases Chile's export opportunities and strengthen its position as a major global supplier.

Globally, the main import markets for low-emissions hydrogen are Japan, Korea and Europe. Although Australia and the Middle East are closer to potential importers in Asia, Chile benefits from direct maritime routes that avoid major potential chokepoints such as the Strait of Hormuz, the Bab-el-Mandeb Strait and the Strait of Malacca. When hydrogen is transported as ammonia or other liquid synthetic fuels, the farther distance from Chile only adds marginally to costs, increasing the levelised cost of hydrogen by around USD 0.2/kg H_2. For exports to Europe, Chile faces competition from suppliers in North Africa and elsewhere that are closer to European markets, and from suppliers in Latin America such as Brazil whose shipping routes to Europe do not involve passing through potential chokepoints such as the Panama Canal. Concerns about energy security may prompt importing countries to diversify hydrogen supply, as reflected by the four regional lots under H2Global supply tenders[6], which includes one for Latin America, together with Australia, funded by Germany. Regulatory uncertainty around low-emissions hydrogen definitions, critical for export eligibility and securing offtake agreements, may however affect timely project development (see Box 4.1).

Box 4.1 ▻ International standards for hydrogen intended for exports

Several countries and regions, including the European Union, India and the United Kingdom, already have certification schemes defining methodologies to quantify hydrogen-related greenhouse gas (GHG) emissions. Others, such as Japan and Korea, have announced thresholds, but are still developing measurement rules. Chile will need to measure the environmental attributes of hydrogen using standards compatible with key demand markets, even if their thresholds differ. These standards should be aligned with International Standards Organization (ISO) standards to ensure comparability and international recognition, and in particular the ISO 19870 series to provide standardised methodology to calculate GHG emissions from the entire hydrogen value chain.

Low-emissions hydrogen projects announced in Chile plan to use water electrolysis. Most intend to use dedicated solar photovoltaics (PV) and wind power, which will mean zero

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[6] H2Global is a double-auction mechanism that supports international trade in low-emissions hydrogen by awarding long-term, fixed-price supply contracts through the intermediary Hintco, which then runs short-term auctions to sell the low-emissions hydrogen. The fund provider covers the gap between supply and demand prices.

emissions (excluding embedded emissions from assets, which are not covered by current thresholds). However, some grid electricity that involves emissions may still be used, for example to ensure the stable operation of the electrolysers, and the emissions from grid electricity attributable to a project would need to be included. If less than 20% of grid-connected electricity is used with today's grid emission factor (189 kilogrammes of carbon-dioxide equivalent per megawatt-hour [kg CO_2-eq/MWh]), it would still comply with the GHG emissions thresholds set by the European Union (3.38 kilogrammes of carbon-dioxide equivalent per kilogramme of hydrogen [kg CO_2-eq/kg H_2]), Japan (3.4 kg CO_2-eq/kg H_2) and Korea (4 kg CO_2-eq/kg H_2). Well-to-wheel frameworks, such as used in the European Union, also require emissions associated with shipping to be accounted for, and these can be as high as 1 kg CO_2-eq/kg H_2.

4.2.3 Stimulating domestic demand

In the late 1980s, a methanol facility was established in the Magallanes region in Chile to make use of the area's abundant natural gas resources. By 2024, the region produced over 1 Mt of methanol per year, or around 1% of global supply, for export to other Latin American and Asia-Pacific markets.

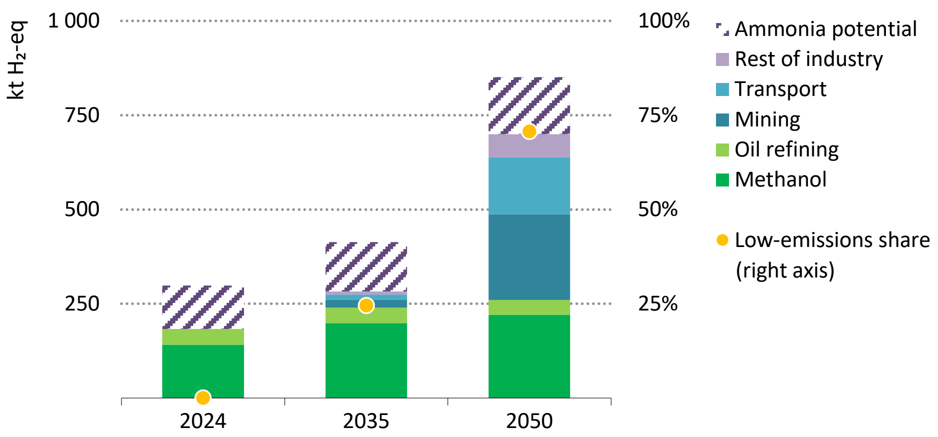
Most announced low-emissions hydrogen projects in Chile have been similarly shaped by expectations of future export opportunities amid limited domestic demand, a trend also seen in project announcements in other Latin American and African countries. However, domestic demand can create the enabling infrastructure and expertise needed for a subsequent scaling-up of production, helping to make Chile a more attractive destination for international investment geared to the export market.

Initially, Chile's efforts to create domestic demand focused on heavy-duty road transport and off-road mining machinery for surface operations. Support from CORFO under the HidroHaul programme supported the first hydrogen refuelling station and the development of hydrogen fuel cell trucks which entered service in 2025. However, technological readiness constraints and the increasing competitiveness of direct electrification are limiting the deployment of hydrogen in those areas, and Chile's focus has gradually shifted toward other applications that could bolster domestic demand and substitute imports, including in particular the production of ammonia and ammonia-based products (Box 4.2).

The APS sees annual domestic consumption of hydrogen and hydrogen-based fuels rise from around 180 kt H_2-eq in 2024 to 280 kt H_2-eq in 2035 and almost 700 kt H_2-eq in 2050, while the share of low-emissions hydrogen and hydrogen-based fuels in total domestic consumption increases from almost zero today to 70% in 2050, particularly in the industry and transport sectors (Figure 4.4). In the STEPS, growth of domestic consumption is almost entirely confined to existing conventional uses, reaching less than half the level of demand in the APS.

In the transport sector, electrification is the dominant technology for achieving emissions reductions. However, complete electrification of heavy-duty, long-haul trucking is difficult to achieve. In the APS, hydrogen supplements electrification, with some fuel cell electric vehicles used in road transport adopting a hybrid approach in which hydrogen extends the range of the battery. By 2050, hydrogen meets 20% of heavy-duty freight transport needs. Hydrogen for road freight relies on a hydrogen distribution network: this increases delivered fuel costs, but careful planning of the location of refuelling stations around the existing road network can keep these costs to a minimum. The mining industry also deploys hydrogen for heavy-duty off-road mobile applications (see Chapter 2).

Figure 4.4 ▻ **Domestic consumption of hydrogen and hydrogen-based fuels in Chile by sector in the APS, 2024-2050**



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Hydrogen and hydrogen-based fuel consumption almost quadruples to 2050, and there is further potential for growth from onshoring ammonia production

Notes: kt = kilotonnes; H_2-eq = hydrogen equivalent. Ammonia potential reflects the hydrogen demand required to replace existing conventional ammonia uses, including direct imports and indirect imports as fertilisers like urea, but doesn't include emerging uses, like as a fuel for shipping or in power plants.

Existing industry and refineries could use hydrogen to reduce natural gas imports

About half of the oil consumed in Chile is refined domestically. Refineries currently consume about 3 petajoules (PJ) of natural gas for hydrogen production, about 1% of total natural gas consumption in Chile. Using domestically produced low-emissions hydrogen instead of hydrogen produced from fossil fuels in refineries could be a cost-effective way to stimulate domestic hydrogen demand. Of Chile's three existing oil refineries, the Gregorio refinery in Magallanes is particularly well placed to make use of domestic low-emissions hydrogen. ENAP, Chile's state-owned oil and gas company which operates the Gregorio refinery, is building its experience in hydrogen production with a project for a 1 megawatt (MW) electrolyser nearing completion in this region.

Today steel production in Chile is limited to scrap recycling in electric arc furnaces (EAFs). EAFs have a relatively low thermal energy demand which is usually served by gas. In the APS this reaches nearly 0.5 PJ in 2050, or 0.1% of industry energy demand, which could be supplied by hydrogen, but it is negligible compared to the industrial sector as a whole, and higher hydrogen demand from iron and steel production relies on emerging technologies that use low-emissions hydrogen to produce direct reduced iron (DRI). However, adding new production capacity is challenging in the current market: Chile's Huachipato blast furnace closed in 2024 because of cost pressures caused by global overcapacity in primary steel production.

A new near-zero emissions H_2 DRI plant with the same production capacity as the Huachipato blast furnace would add around 90 kt to domestic hydrogen demand, and could take advantage of the domestic production of iron ore. (Iron ore in Chile has an iron content of 66.7%, which is higher than in many other major producing regions, and is close to the 67% grade required for DRI). Demand-side measures, like dedicated procurement strategies, and supply-side measures, like financing support to reduce project risks, would be needed to stimulate new production. Domestic steel production would reduce the need for imported iron and steel, on which Chile spent over USD 3 billion in 2023, and is likely to spend more in future years in the wake of the closure of the Huachipato plant. New hydrogen DRI plants could also facilitate the replacement of iron ore exports with exports of higher value hot briquetted iron.

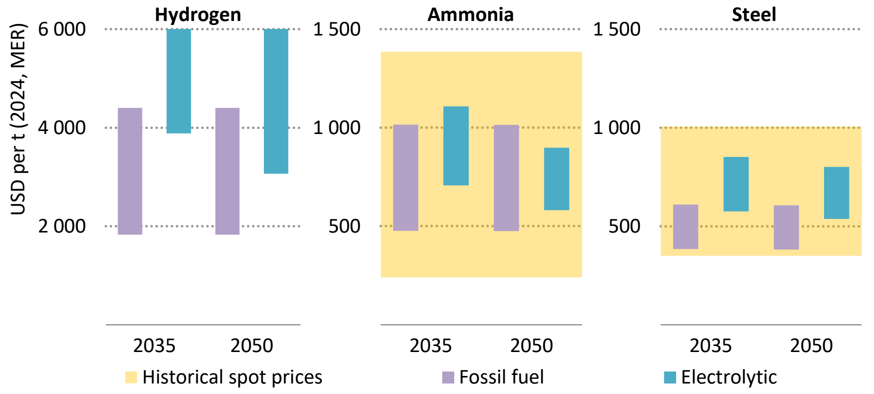
Box 4.2 ▹ Electrolytic hydrogen for a new domestic ammonia industry in Chile

Ammonia is an important feedstock for the production of fertilisers and explosives used in mining. In 2023, Chile imported 350 kt of ammonia, mostly from Trinidad and Tobago, and the United States, for use in the production of mining explosives at the Prillex América plant in Mejillones. In addition, it indirectly imported around 250 kt of ammonia in the form of fertilisers, 90% of which were urea. Chile spent USD 180 million on imports of ammonia for mining explosives in 2024, and USD 440 million on nitrogen-based fertilisers, the cost of which has risen in recent years because of globally high natural gas prices.

The demand for industrial materials in the APS is based on a continuation of historical trends and projects a continuation of ammonia imports to Chile. However, technological improvements and a fall in the costs of electrolytic production could enable an emerging domestic ammonia industry to become competitive at the upper-end of historical spot market prices (Figure 4.5).

Chile has a long history of domestic fertiliser production: as global populations grew rapidly in the late 19th century, it played a critical role in the associated expansion of the agriculture sector as one of the first exporters of fertilisers extracted from local deposits of saltpetre. Concerns over the long-term sustainability of imported mined fertilisers helped to spur the invention of the Haber-Bosch process in Europe in the early 20th century: this displaced Chile's exports by enabling the production of synthetic fertilisers using nitrogen captured from the air, and over time changed Chile into an importer of ammonia and ammonia-based products.

Figure 4.5 ▹ Levelised cost of production for key industrial products using fossil fuel and hydrogen-based technologies in Chile in the APS, 2035 and 2050



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Domestic industries using local electrolytic hydrogen become more competitive over time, particularly for the production of ammonia

Notes: t = tonne. Historical ammonia prices are based on free on board in the Middle East between 2022 and September 2025. Historical steel prices are based on aggregated steel spot markets. Cost range for technologies reflects only variation in energy price and not in other costs. Natural gas prices vary from USD 9 to 25 per gigajoule, reflecting the historical range in natural gas prices for industry in Chile over the last 15 years. Electrolytic hydrogen prices consider a range of renewables generation technologies and resource qualities. The production routes for hydrogen are steam methane reforming (fossil fuel) and electrolysis with dedicated off-grid renewables. The same routes are used for ammonia production, with Haber-Bosch synthesis costs also included. Fossil fuel-based steel costs use a blast furnace and basic oxygen furnace; electrolytic steel uses 100% electrolytic-hydrogen direct reduced iron and an electric arc furnace. Levelised costs of production do not include subsidies or carbon prices.

Domestic hydrogen demand could increase by 60 kt if the ammonia used for explosives production today were produced in Chile, instead of being imported. Projects to produce ammonia for this purpose are already underway, including at the existing plant in Mejillones. Additional production could displace other imports of mining explosives or even create enough spare capacity for an export market. Demand for mining explosives in Latin America is expected to grow by 5-8% in the next decade, driven by declining ore grades and increasing demand for critical minerals. On the other hand, new emulsion technologies used as mining explosives could suppress demand for nitrogen-based explosives.

Replacing the nitrogen demand from current imported fertilisers with domestic ammonia production could increase hydrogen demand by 45 kt. However, directly substituting fertilisers with low-emissions ammonia may be challenging because of the reliance on urea of industries in Chile. Although urea is easy to store and transport, its production requires a carbon dioxide (CO_2) feedstock. Conventional urea production sources CO_2 from the fossil fuels used to produce hydrogen, but this is not possible when hydrogen is produced electrolytically because it has no direct onsite CO_2 emissions. Unless the domestic agriculture sector is willing and able to switch to fertilisers which do not require a carbon feedstock, like ammonium nitrates and their derivatives, then low-emissions plants need to be co-located with other sources of CO_2 if the ammonia they produce is to be used for fertiliser production. The pulp and paper industry could provide more than 14 Mt/year of biogenic CO_2, which is far more than required to satisfy a urea demand of around 0.2 Mt CO_2, and synergies between these industries could help accelerate the deployment of a domestic industry.

Leveraging biogenic CO_2 waste streams for hydrogen-based fuel production

Low-emissions hydrogen and CO_2 can be combined to produce synthetic fuels. Because the CO_2 embedded in these fuels is ultimately re-emitted during combustion, their sustainability depends entirely on the carbon and hydrogen sources from which they are produced. Making use of both Chile's biogenic CO_2 resources and its low-emissions hydrogen potential could enable the country to become a competitive supplier of synthetic fuels for both domestic and export markets, notably for aviation and marine bunkering, i.e. supplying fuel to ships.

By-product CO_2 from bioethanol and biogas plants costs around USD 20-30/t CO_2, and is one of the least expensive sources of CO_2 because of its high concentration in process streams. However, the availability of these concentrated sources is limited: they account for only 3% of the biogenic CO_2 currently generated in industrial process streams in the world. Diluted biogenic sources in combustion flue gases – such as pulp and paper mills, biomass power plants, and waste incinerators – are another source of supply, but capture costs are typically higher at around USD 85/t CO_2. Pulp and paper production is the largest source of biogenic CO_2 emissions, accounting for nearly 60% of the CO_2 released from industrial biogenic process streams globally. In kraft pulp mills, most of these emissions arise from the combustion of black liquor[7] in chemical recovery boilers and hog fuel[8] in dedicated boilers. CO_2 captured from the exhaust gases of these boilers, combined with low-emissions hydrogen, could be used in the production of methanol or other synthetic fuels, and at the same time provide an additional revenue stream for the industry.

In the APS, global demand for low-emissions methanol, excluding bio-methanol, for shipping and as a chemical feedstock reaches almost 135 Mt by 2050, while demand for synthetic

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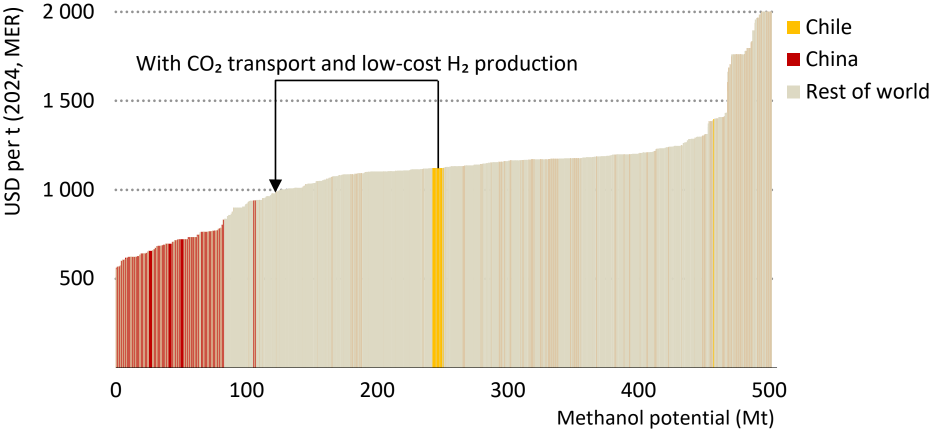
[7] Black liquor is a by-product of the kraft pulping process that contains dissolved lignin, hemicelluloses and spent cooking chemicals used to separate cellulose fibres in the wood. It retains more than half of the original wood's energy content.

[8] Hog fuel is a mix of wood waste by-products such as bark, sawdust, chips and forestry residues.

kerosene increases to around 45 Mt. Chile could produce up to 10 Mt of synthetic methanol or 4 Mt of synthetic kerosene if its available biogenic CO_2 resources were used exclusively for that purpose.

Pulp manufacturing in Chile generates an estimated 14 Mt/year of biogenic CO_2 from flue gas streams. While no formal initiatives have yet been announced to capture and use biogenic CO_2 from pulp mills in the country, similar efforts are beginning elsewhere; for example, collaborations between utility company Eletrobras and pulp and paper producer Suzano in Brazil are exploring the production of synthetic fuels from biogenic CO_2.

Figure 4.6 ▷ Levelised cost of methanol production using electrolytic hydrogen and captured biogenic CO_2 from industrial process streams, 2030



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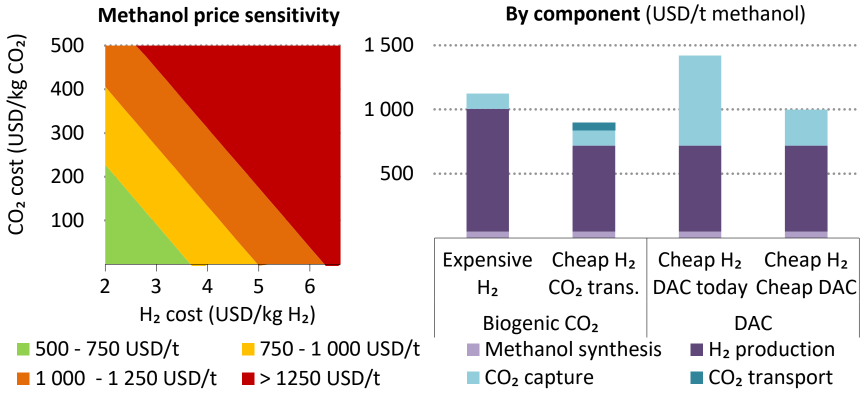
Transporting biogenic CO_2 to areas of low-cost hydrogen production could enable Chile to become a competitive supplier of low-emissions methanol

Notes: Hydrogen production is based on the lowest cost configuration among solar PV, onshore wind and battery systems among all suitable sites within 200 km of the carbon dioxide (CO_2) emission source. Technology assumptions follow the IEA Stated Policies Scenario for 2030. The analysis includes only biogenic CO_2 sources with emissions more than 100 kt CO_2/year, or clusters of facilities within a 30 km radius emitting a combined 100 kt CO_2/year. Biogenic emission sources include: bioethanol plants (global); biogas upgraders to biomethane (Europe and the United States only); biomass-fired power plants (global); waste incinerators (global); and pulp and paper mills (global). The assumed levelised costs of capture are: USD 25/t CO_2 for bioethanol; USD 30/t CO_2 for biomethane; and USD 85/t CO_2 for other plants.

Source: The levelised cost of hydrogen was calculated by Jülich Systems Analysis at Forschungszentrum Jülich using the ETHOS model suite.

The lowest hydrogen production cost in Chile is around USD 3/kg H_2 by 2030, but the levelised cost of electrolytic hydrogen is around USD 5/kg H_2 in the region where most biogenic CO_2 sources are located. At this price, methanol production costs would exceed USD 1 100/tonne (t) methanol, given that hydrogen accounts for around 85% of total methanol costs. Under these conditions, methanol production would be more cost competitive in China, and in some parts of Europe and the United States. If CO_2 from the regions where paper mills are located could be transported to northern Chile, where hydrogen costs less to produce, methanol could be produced for less than USD 1 000/t, including the USD 40/t cost of CO_2 transport per 1 000 kilometres (km) by ship. At this price, Chile could become a competitive producer (Figure 4.6). While China and other countries might well still be able to produce methanol at a lower average cost, growing global demand and the need for diversified supply sources would leave ample room for Chile to emerge as a competitive supplier.

Figure 4.7 ▻ Methanol price sensitivity and indicative production cost of methanol by cost component in Chile



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Cheap low-emissions hydrogen and CO_2 are key for low-cost methanol today; falling DAC costs would make hydrogen costs the largest driver of methanol competitiveness

Notes: DAC = direct air capture. *Expensive H_2* refers to a low-emissions hydrogen cost of USD 5/kg H_2, corresponding to the optimised levelised cost in the in the regions where Chile's paper mills are located. *Cheap H_2* refers to a low-emissions hydrogen cost of USD 3.5/kg H_2, representing the optimised levelised cost in the lowest cost area of Chile. When CO_2 transport is included, a distance of 1 200 kilometres (km) by ship is assumed, with a transport cost of USD 45/t CO_2. *DAC today* corresponds to a CO_2 capture cost of USD 500/t CO_2, while *Cheap DAC* assumes a future cost of USD 200/t CO_2. USD are expressed in 2024 values using MER.

Source: IEA analysis based on Global CCS Institute (2025).

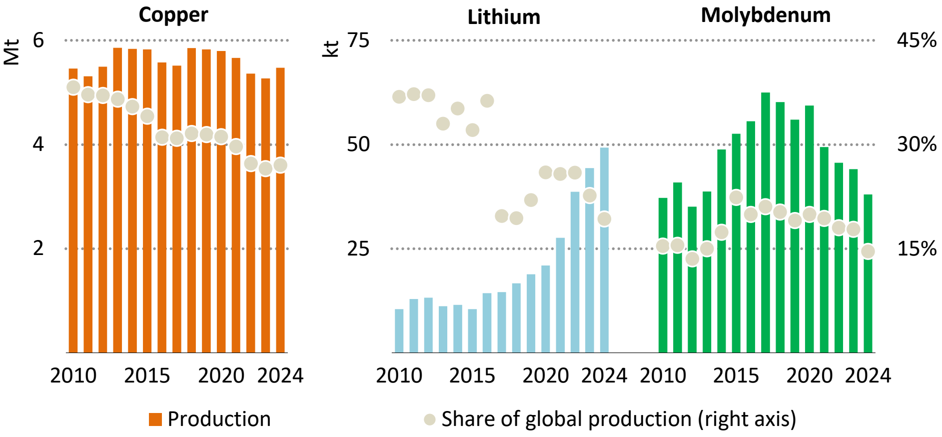
In the medium term, while global demand for synthetic liquid fuels, whether methanol or kerosene, remains modest, access to low-cost hydrogen will be essential for Chile to be a competitive supplier. Without it, regions with similar CO_2 availability but lower hydrogen costs could produce these fuels more economically. In the longer term, the limited availability of biogenic CO_2 becomes a more important constraint as demand for synthetic liquid fuels expands (Figure 4.7). At that stage, the trade-off shifts to whether it is more cost effective to produce fuels using slightly more expensive hydrogen paired with biogenic CO_2, or to rely on direct air capture (DAC) combined with cheaper hydrogen. Assuming DAC CO_2

remains around USD 400/t CO_2 more expensive than post-combustion CO_2 capture, production based on biogenic CO_2 could remain cost competitive even if hydrogen costs are up to USD 3/kg H_2 higher. In this context, transporting CO_2 continues to support cost efficiency and higher margins. However, if DAC costs fall to around USD 200/t CO_2, as some long-term estimates indicate, the balance shifts: DAC-based production becomes more attractive where hydrogen can be produced for only USD 0.8/kg H_2 less than in regions relying on biogenic CO_2, a situation that could favour Chile's northern and southern regions. Ultimately, this suggests that the future production of methanol and synthetic kerosene will depend less on the availability of CO_2 and more on where electricity, and therefore the costs of hydrogen and DAC, are cheapest.

4.3 Critical minerals for the energy transition

Mining is the second-largest industry in Chile after the services sector, and it plays a vital role in its economy. Over the past decade, mining has accounted for more than 10% of gross domestic product and provided more than 10% of direct and indirect employment. Chile is currently the world's largest producer of copper, the second-largest producer of molybdenum, and the third-largest producer of lithium, all of which are critical minerals of vital importance for the energy industry (Figure 4.8). Unlike mining in other countries, which is often dominated by bulk commodities such as iron ore and alumina, the mining sector in Chile is uniquely centred around today's most critical minerals. Copper and lithium, which together account for over 85% by value of its mining exports in 2024, are expected to become even more important as electrification increases and demand for batteries rises.

Figure 4.8 ▻ Lithium, molybdenum and copper production in Chile, 2010-2024



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Chile has supplied on average 20-30% of all the copper, lithium and molybdenum used worldwide in recent years

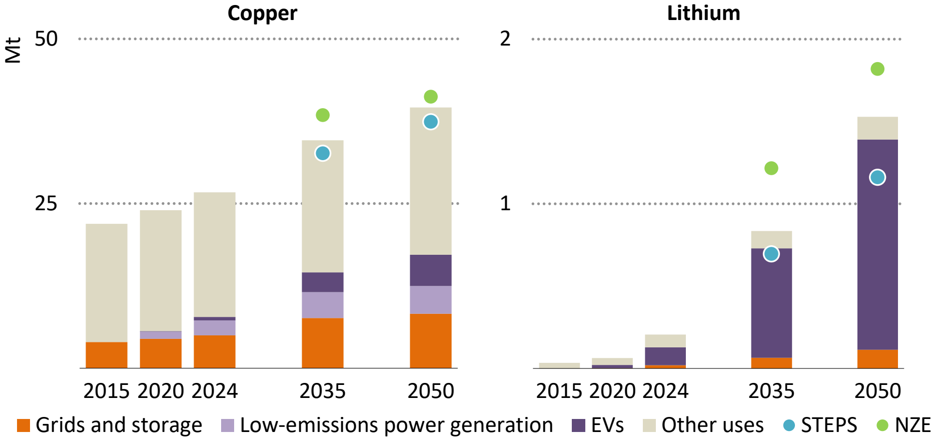
4.3.1 Global outlook

Global demand outlook

Copper is the only critical mineral used in all major clean energy technologies, including electric vehicles (EVs), solar photovoltaics, wind power and power grids. This is due to its high electrical conductivity, durability, ductility and corrosion resistance. In 2024, global refined copper demand, excluding direct-use scrap, was approximately 27 Mt. In the APS, global demand rises to about 35 Mt by 2035 and 40 Mt by 2050. Although construction and power grids remain the largest uses of copper, EVs are the fastest growing source of demand: their share of the global copper market is projected to rise from 2% in 2024 to 12% by 2050. Global copper demand from the solar, wind and construction sectors together increases by approximately 50% between 2024 and 2050.

Rising EV sales have led to a tripling of demand for lithium since 2020, and demand is expected to triple again around the end of the decade. Nearly 90% of this projected demand growth reflects EV requirements, but investment in electricity storage is expected in the APS to triple by 2030, and this also contributes to demand growth (Figure 4.9).

Figure 4.9 ⊳ World copper and lithium demand by sector in the APS relative to the STEPS and NZE Scenario, 2015-2050



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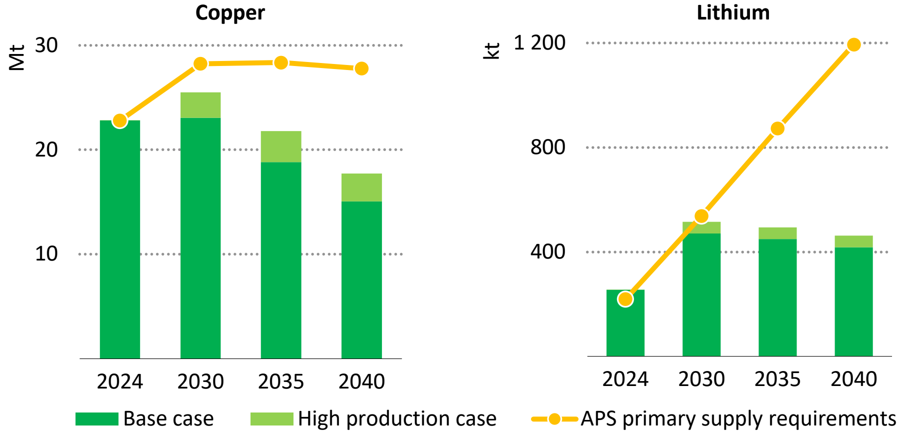
Driven by the energy transition, by 2050 copper demand rises 50% and lithium demand increases more than sevenfold

Global supply and demand balances

Among key energy minerals, copper and lithium are the most exposed to future supply-demand gaps (Figure 4.10).

The current pipeline of copper mining projects suggests a potential supply shortfall of up to 30% by 2035 due to limited new discoveries and factors such as declining ore grades, rising capital costs and long project lead times. However, recycling is expected to play a growing role to respond to growing demand, with secondary supply meeting 22% and 40% of global demand in 2035 and 2050 respectively, stabilising annual primary supply requirements below 30 Mt in the APS.

Figure 4.10 ⊳ Global mined copper and lithium supply from existing and announced projects, and primary supply requirements in the APS to 2040



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Surging demand for copper and lithium means that supply will fall short of demand unless new projects are added to the project pipeline

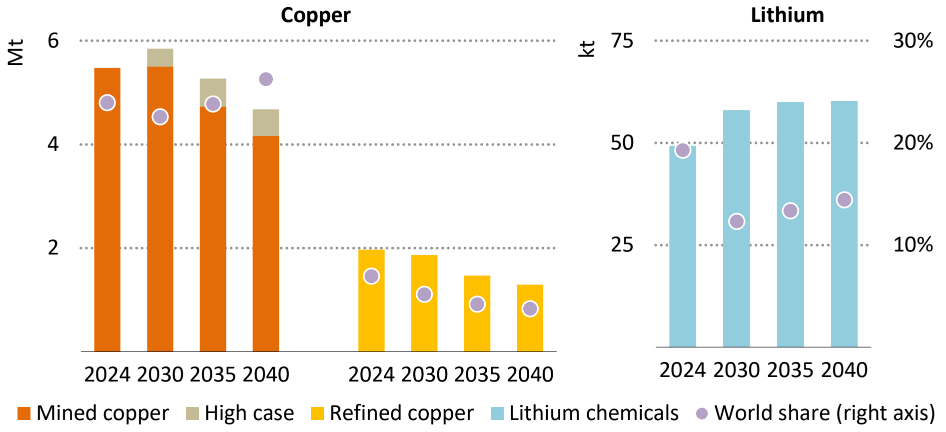
Notes: Primary supply requirements are calculated as total demand net of secondary supply, including accounting for losses during refining operations. The base case includes production from existing assets and those under construction, along with projects that have a high chance of proceeding. The high production case additionally considers projects at a reasonably advanced stage of development, seeking financing and/or permits.

Existing and announced projects for lithium are projected to produce close to 500 kt every year (about 2 500 kt in lithium carbonate equivalent by 2030), and this is enough to keep markets well supplied in the APS. After 2030, rapidly growing demand is expected to push the market into deficit. However, there is a better prospect of new lithium projects being added to the pipeline to meet rising demand than for copper, as they face fewer geological constraints and involve shorter lead times.

4.3.2 Outlook for critical mineral production in Chile

While Chile is set to remain a key producer of lithium and copper, the pipeline of planned projects suggests that domestic production of both metals could stabilise beyond 2030-2035, and would then decline for copper (Figure 4.11).

Figure 4.11 ▷ Outlook for copper and lithium production in Chile, 2024-2040



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Announced projects indicate that Chile's copper production is set to level off by 2030 and then decline, whereas lithium output stabilises

Notes: The base case includes production from existing assets and those under construction, along with projects that have a high chance of proceeding. The high production case additionally considers projects at a reasonably advanced stage of development, seeking financing and/or permits.

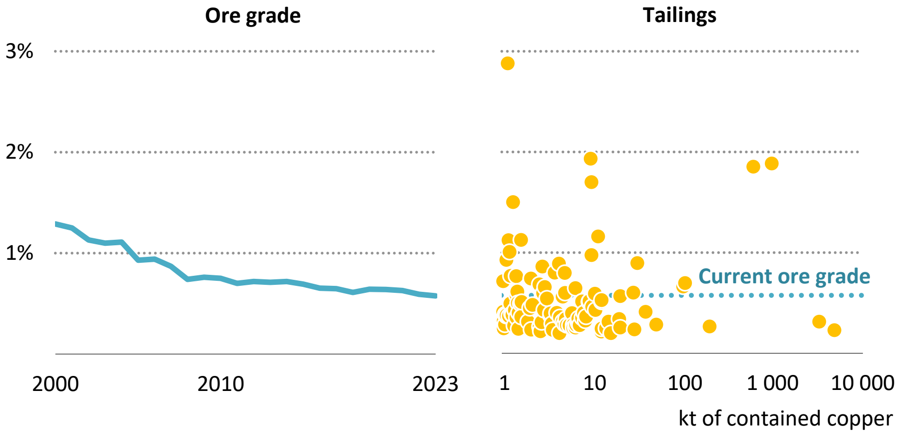
Outlook for copper in Chile

The base case project pipeline indicates that short-term growth in copper production in Chile is expected from major new projects at the Collahuasi and Quebrada Blanca mine, increased production from Codelco assets, expansion of the Centinela mine, and recovery of production at the Los Bronces mine. Despite this, the project pipeline suggests that copper production in Chile could peak by 2030 and then decline to around 4 Mt (4.5 Mt in the high case, which additionally considers projects at a reasonably advanced stage of development, and those seeking financing and/or permits). As Chile is the world's largest copper producer, a drop in its output would have a significant impact on global supply.

The challenges facing the copper industry in Chile include declining ore grades, rising capital costs, fewer resource discoveries, and water scarcity (Figure 4.12). Over the past 20 years, the average copper ore grade in Chile declined by a third from 0.9% to 0.6%, reflecting a global trend of resource depletion. Higher volumes of ore will have to be processed to maintain production levels, which could increase unit production costs and intensify the environmental and social impacts of mining activities.

Reprocessing tailings, i.e. waste after ore processing, is gaining attention as a response to these challenges. Approximately 2 Mt of copper contained in historic tailings are currently distributed across 100 sites in Chile. These tailings contain higher grade copper than currently mined ores, and reprocessing them is economically viable. On current trends, the amount of high-grade copper in these tailings could reach 5.6 Mt by 2050, nearly three-times the current level. This suggests that tailings could play a strategic role to alleviate future copper supply shortages, improve resource efficiency and support the sustainability of the copper industry in Chile. The re-use of tailings may also simplify mine closure plans and reduce associated costs.

Figure 4.12 ▷ Copper: average concentrations contained in ore grade versus tailings in Chile



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Recovering copper from tailings could increase supply, boost resource efficiency and improve the sustainability of Chile's copper industry

A by-product of copper mining, molybdenum is produced in Chile at mines such as Chuquicamata and El Teniente, and output depends on the continued operation of these copper mines. Molybdenum is an essential metal used in high resistance stainless steel as well as super alloys. It contributes to corrosion resistance and high temperature strength, and has applications in the energy sector that range from oil and gas drilling and pipelines to geothermal energy.

Outlook for lithium in Chile

Chile is part of the so-called lithium triangle spanning Argentina, Bolivia and Chile, and the country holds around 30% of global lithium reserves. Its lithium is primarily extracted from brine and then refined locally into carbonates. This method of production has a lower carbon footprint than hard rock mining. Chile is well placed to benefit from rising demand for lithium iron phosphate (LFP) batteries, which are gaining market share due to cost and safety advantages, and whose production generally uses lithium carbonate directly.

Chile is set to remain the leading producer of lithium in South America. Planned investment suggests that domestic production could rise by 10 kt from today's level to around 60 kt (about 320 kt in lithium carbonate equivalent) before 2035. The Atacama region remains a key hub for lithium extraction from brine, with potential for expansion if regulatory and environmental hurdles are addressed.

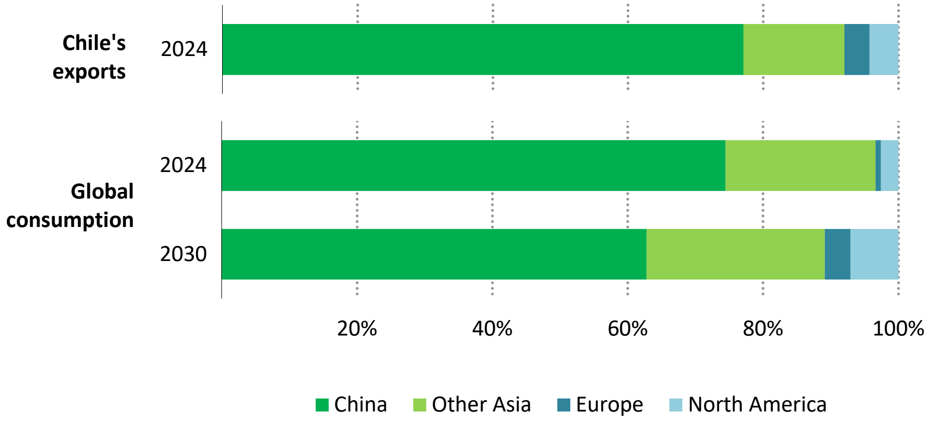
4.3.3 Export opportunities and new markets

Lithium and copper production in Chile is overwhelmingly export-oriented. Chile is a key supplier to many markets and trading partners. Its exports of lithium and copper are important for supply diversification and enhance the resilience of international value chains.

Lithium trade

Chile is responsible for around 25% of global lithium exports. In 2024, 92% of its lithium exports went to markets in Asia, particularly China. It is also a major exporter to the United States, supplying 50% of its demand, and to the European Union, supplying 80% of its lithium demand (Figure 4.13).

Figure 4.13 ▷ Lithium chemical exports from Chile and world global consumption by region, 2024-2030



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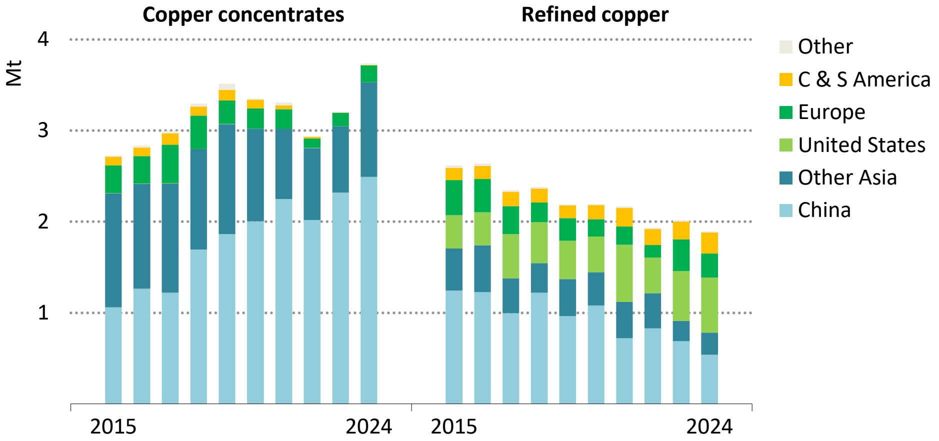
Today, China is the main export destination for lithium from Chile; exports to the United States and Europe are set to grow as global lithium demand diversifies

Copper trade

Chile is the world's leading copper exporter, supplying around 26% of global copper ore and concentrate exports (Figure 4.14). About 70% of its copper ore exports go to China, and 28% to other Asian markets, reflecting their role in global manufacturing. Chile accounts for 30-40% of the market for copper imports in Japan, India and Korea, and is also a major supplier to a number of countries.

Figure 4.14 ⊳ Refined copper and ore exports from Chile by destination, 2015-2024



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Refined copper exports to Europe and the United States have declined, while exports of ore concentrate to Asia have increased

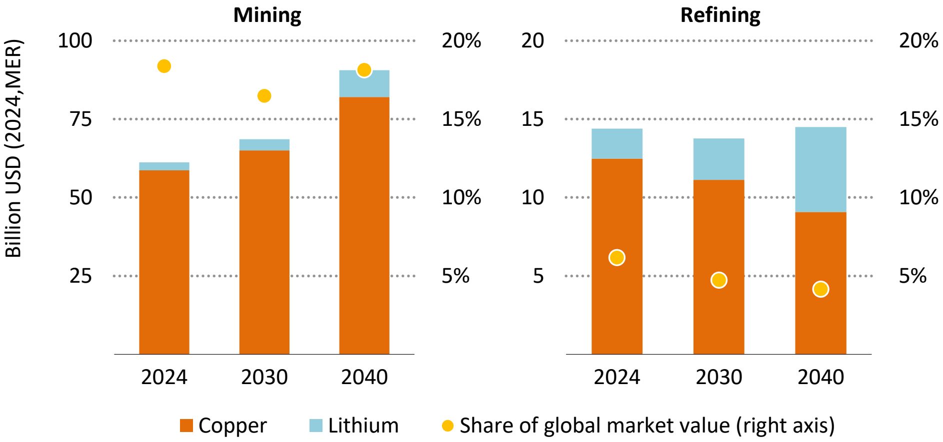
Notes: C & S America = Central and South America. Volumes are in copper content.

Chile's infrastructure and trade links could allow it to capture more value from its copper production through logistics, processing and services linked to the mining sector. As part of its wider trade strategy, the Chilean government announced an action plan in April 2025 for the Capricorn Bioceanic Corridor (CBC) at a cost of USD 92 million. The CBC is a rail corridor designed to connect ports in southern Brazil via Paraguay and Argentina to Chile's Pacific coastal hubs of Antofagasta, Iquique and Mejillones. Its planned route crosses the Atacama Desert where copper and lithium mines in Chile are concentrated. This project has the potential to diversify its options for export routes and to strengthen its position as a key producer and exporter of mineral resources. In 2023, Chile has agreed a framework with the European Union to strengthen economic co-operation with an aim to facilitate increased trade of raw materials, including lithium and copper.

Revenue

The total market value of critical minerals in Chile is projected to rise above USD 100 billion by 2040, with copper revenue tripling from today's level and accounting for more than USD 80 billion of the 2040 total. This implies that Chile will secure close to one-fifth of global mining revenue for key energy transition minerals through to 2040 (Figure 4.15).

Figure 4.15 ⊳ Market value of mined and refined critical mineral production in Chile in a base case, 2024, 2030 and 2040



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Chile could capture close to one-fifth of global critical minerals mining revenue through to 2040

Notes: The base case includes production from existing assets and those under construction, along with projects that have a high chance of proceeding to development. Global critical mineral mining revenue is assessed based on six minerals – copper, lithium, nickel, cobalt, graphite and rare earth elements. Market value was calculated by multiplying regional production volume in the base case with current market price for final products, taking into account refining margins.

Box 4.3 ⊳ Local value added and regional integration

For many key energy technologies, manufacturing requires more than one critical mineral, and there are potential synergies between copper and lithium mining output in Chile and mining projects elsewhere in Latin America. These synergies could boost regional co-operation and shared value creation. Existing and planned production of nickel could reach 90 kt and graphite at 70 kt per year in Brazil in 2035, and working with Chile's well-established lithium mining industry could supply battery production. Rare earths mining projects in Brazil could similarly provide key mineral inputs to EV motor production chains.

Although the main industrial consumers of these critical minerals are currently located outside of Latin America, downstream manufacturing is beginning to develop in the region. For example, Mexico and Brazil are proceeding with EV manufacturing plants which could boost regional demand for battery materials. However, the mid-stream stages of the value chain, including battery cell production and cathode chemical processing, are at an early stage of development in Latin America. Current battery manufacturing projects are concentrated in Mexico, and regional capacity to convert mined minerals into the specialised chemicals required is still limited, though BYD, a Chinese manufacturer, has announced plans for an integrated complex in Brazil that combines EV production with the processing of upstream materials such as lithium and iron phosphate.

Chile directly produces lithium from brine and refines it into battery-grade chemicals. Moving into higher value parts of the supply chain, for example the production of cathode active materials and their precursors, requires access to energy, processing inputs and specialised technical skills. Strengthening industrial links within Chile and across the region would help create a more integrated and competitive Latin American supply chain, and this could lead to new jobs and industrial activities in Chile and elsewhere in the region.

4.3.4 Environmental impacts and management

Lithium

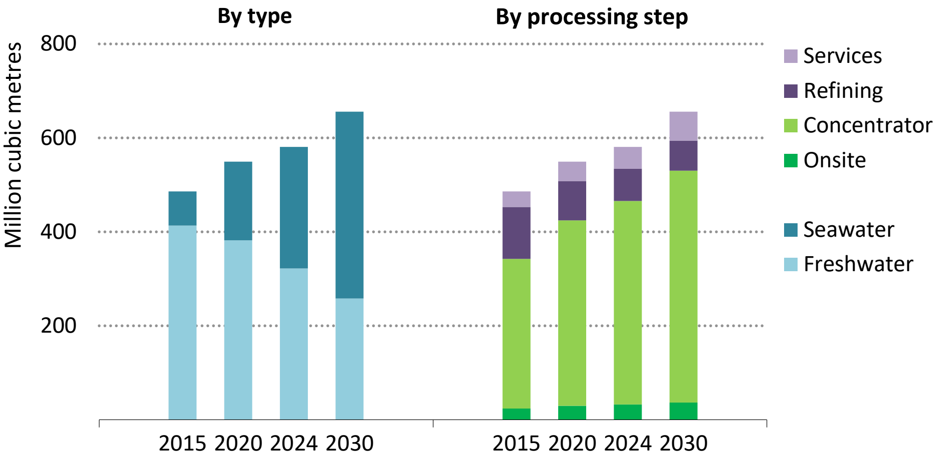
Chile primarily uses a method of lithium production that involves evaporating brine to extract lithium. This requires less energy than producing lithium from hard rock ore through the use of roasting, which is the process used in some other countries. Chile has recently prioritised the adoption of direct lithium extraction (DLE) technology, which is reflected in the National Lithium Strategy announced in 2023. DLE technology is expected to use less water and have less of an environmental impact than the evaporation ponds currently used in Chile. However, while recent reports suggest that DLE methods have the potential to unlock more sustainable production, they use more energy than evaporation ponds, and may require additional grid power capacity: as a result, there is a need for protocols to assess and manage the potential impacts of the brine reinjection technology used in DLE (Bunel, 2024).

Some mining companies have set GHG reduction targets and are now signing power purchase agreements with renewable energy providers to source clean electricity and reduce emissions. For example, the SQM company aims to produce carbon neutral lithium by 2030 and to be carbon neutral by 2040, while in 2024 the company Albemarle committed to using 100% renewables electricity for its Salar de Atacama and La Negra operations in Chile. Ensuring that these projects have access to a well-developed power grid is crucial for their success.

Water consumption in copper production

In a high production case (see section 4.3.2), total water demand from the copper mining industry in Chile increases at an average annual rate of 1% over the next decade and to over 650 million cubic metres (m^3) by 2035. Rising water demand in the copper industry mostly reflects the use of more water-intensive flotation processes and a decline in ore grades which means that more ore has to be processed in order to maintain production levels (Figure 4.16).

Figure 4.16 ▷ Water consumption in copper production in a high production case in Chile, 2015-2030



IEA. CC BY 4.0.

Despite growing requirements for water that reflect a decline in ore grades, freshwater consumption falls as desalination capacity increases

Note: A high production case considers projects at a reasonably advanced stage of development and that are seeking financing and/or permits.

Copper mining in Chile is shifting to the use of seawater as part of a broader effort to address freshwater scarcity. Since 2015, freshwater demand from the copper industry has declined from 400 to 320 million m^3, and it is expected to fall to around 250 million m^3 by 2030. This shift reflects completion of major seawater desalination projects that have more than tripled the quantity of water sourced from seawater. Virtually all copper projects now at the feasibility or preliminary feasibility stages incorporate seawater desalination. Water production in desalination plants for copper mining is set to reach 400 million m^3 per year by 2030 (see Chapter 2 Box 2.3).

Energy consumption, grids and emissions reduction

The government set a goal to achieve carbon neutrality in the mining sector by 2040 and nationwide by 2050. Currently, emissions from mining account for half of total GHG emissions from the industry sector in Chile. Copper production involves significant emissions due to its use of heavy machinery to transport ore and copper concentrate, and buses for employee transportation. Ore processing at concentrator plants consumes substantial amounts of electricity. Recent trends in copper mining include increased use of seawater desalination, declining ore grades and rising impurity levels, all of which lead to higher ore processing volumes and additional electricity consumption.

The Energy Transition Law, published in December 2024, recognises the importance of the transmission system for the energy transition and provides new tools to reduce the delays that some projects have faced as a result of transmission grid constraints. Initiatives to electrify heavy machinery and to facilitate remote operations are also expected to contribute to future emission reductions. A National Critical Mineral Strategy is being prepared, which includes a review of the economic, social and environmental opportunities and challenges expected to arise from further development of the mining industry in Chile and related upstream and downstream industrial activities. (The sector-by-sector analysis related to reduction of emissions identifies electrification as a key lever for decarbonisation in mining, [see Chapter 2, section 2.4.1]).

Environmental, social and governance

Mining companies in Chile practice environmental stewardship by adopting circular economy practices and pursuing goals such as carbon neutrality, water efficiency and biodiversity conservation. They have adopted robust environmental, social and governance strategies in corporate planning and operations. These strategies aim to align with the UN Sustainable Development Goals and with international industry standards such as those developed by the Global Reporting Initiative, and the International Council on Mining and Metals. For copper, these standards include the Copper Mark, a certification that reflects a commitment to responsible and sustainable mining.

Both lithium producers in Chile, SQM and Albemarle, are recognised as among the most sustainable in the industry as a result of their efforts to measure and report emissions, and participation in the Initiative for Responsible Mining Assurance and its Standard for Responsible Mining Assurance. Specific examples of mining company commitments can be found among copper producers too: Codelco aims to reduce GHG emissions by 70% and water consumption by 60% by 2030; BHP has transitioned to 100% renewable energy at its Escondida and Spence mines, and is targeting net zero emissions by 2050; and the Collahuasi mine aims to achieve carbon neutrality by 2040.

At government level, in 2025 Chile became an implementing member of the Extractive Industries Transparency Initiative, an international framework to support better governance of the sector through increased disclosures and public data availability. Collectively these initiatives indicate that Chile is consolidating its position as a leader of responsible and sustainable mining.

4.4 Climate resilience in the power sector

The extensive nature of the physical infrastructure of power systems means that they are particularly exposed to the impacts of extreme weather events. While the electricity system in Chile has demonstrated resilience in the face of seismic risks, the growing frequency and intensity of climate-related events such as prolonged droughts and severe storms pose new challenges to grid reliability and system planning. Recent decades have seen more frequent heatwaves in Chile, a declining number of frost days, and prolonged droughts, particularly in the central and southern regions. Rising temperatures and changing precipitation patterns are expected to affect all major energy assets in power systems: hydropower output is vulnerable to reduced water availability; thermal plants face cooling constraints during droughts and heatwaves; electricity networks exposed to wildfires and storms; and facilities in floodplains and coastlines face the risk of damage from inundation and storm surges.

This section examines the core principles of climate resilience in the power sector, with a particular focus on climate projections for Chile, their implications for hydropower generation, and the exposure of electricity grids to wildfire risks. It draws on insights from the IEA's National Climate Resilience Assessment for Chile (IEA, 2024), which evaluated its power system exposure to climate-related risks and identified key areas for strengthening power system resilience.

4.4.1 Climate resilience in the power sector

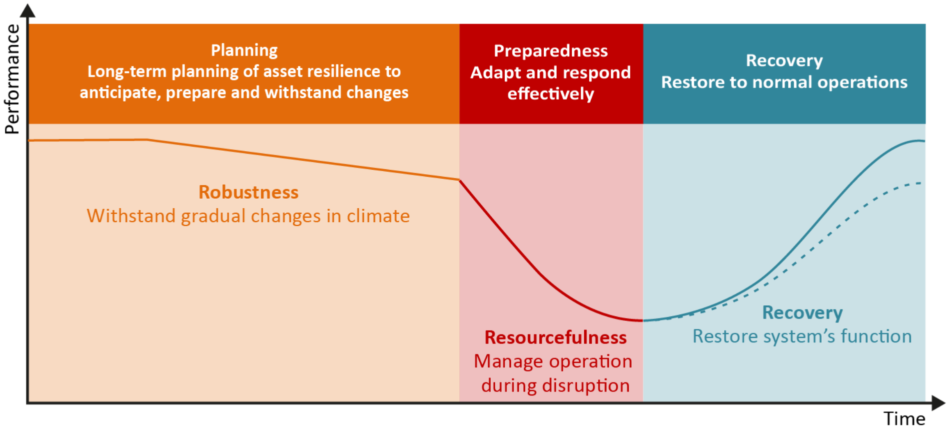
Climate resilience in the power sector refers the ability of a system to anticipate, absorb, accommodate and recover from the impacts of climate-related hazards such as extreme weather, droughts, landslides or heatwaves (IEA, 2022) (Figure 4.17). Climate resilience is a key component of energy security and involves a focus on three core issues:

- **Planning:** Infrastructure and operations must be designed to be able to withstand disruptions.
- **Preparedness:** Systems need to be designed to anticipate potential disruptions and minimise their impact, and system operators need emergency response plans that facilitate effective responses when disruption takes place.
- **Recovery:** System operators and others must be able to respond to disruption quickly and efficiently to restore normal operations.

Understanding climate resilience in the power sector begins with distinguishing between three key concepts: hazard, exposure and vulnerability. Hazard refers to a physical climate-related event such as a drought, heatwave or wildfire: in Chile, hydropower systems are particularly exposed and vulnerable to climate hazards. Exposure relates to the presence of energy assets in areas where these hazards may occur: this would include, for example, hydropower plants located in drought-prone river basins. Vulnerability reflects how susceptible those assets are to damage or disruption, taking account of their design, condition and adaptive capacity.

Enhancing climate resilience, for example through diversified generation, improved forecasting and infrastructure upgrades, helps ensure a more secure, reliable and affordable electricity supply. However, investing in resilience can present short-term affordability challenges, since measures such as grid reinforcement, energy storage or the relocation of vulnerable infrastructure require upfront capital. Sustainable energy planning inevitably means balancing the costs of enhancing resilience with the benefits, for example lower risk of outages, lower recovery costs and improved system reliability.

Figure 4.17 ⊳ Conceptual framework of climate resilience for energy systems



IEA. CC BY 4.0.

Climate resilience enables energy systems to plan, prepare, withstand, adapt and recover from climate-related disruptions

4.4.2 Overview of climate conditions in Chile: recent trends and projections

Diversity of geography and climate zones in Chile means that the impacts of climate change vary significantly by region, with each facing distinct but differing risks. Chile's elongated shape and varied topography pose challenges for national energy planning and infrastructure resilience. The upshot is that region-specific approaches to climate adaptation are needed.

Temperature

The average annual temperature in Chile has increased at a rate of 0.18 degrees Celsius (°C) per decade between 1981 and 2022, and it has experienced eight-of-the-ten warmest years in recorded history in the last two decades. Temperature increases vary in scale with coastal areas warming more slowly than others because of the moderating effect of the ocean. If average temperatures continue to rise, swings between extreme temperatures are likely to become more frequent, with very cold spells in winter and heat waves in summer becoming more frequent.

The Intergovernmental Panel on Climate Change (IPCC) projects Chile's average land surface temperature in a low-emissions scenario (below 2 °C) [9] to be 1.72 °C higher than pre-industrial levels (1850-1900) by mid-century, and 1.78 °C higher by the end of the century. In a high-emissions scenario (above 3 °C)[10], Chile is projected to experience 2.2 °C

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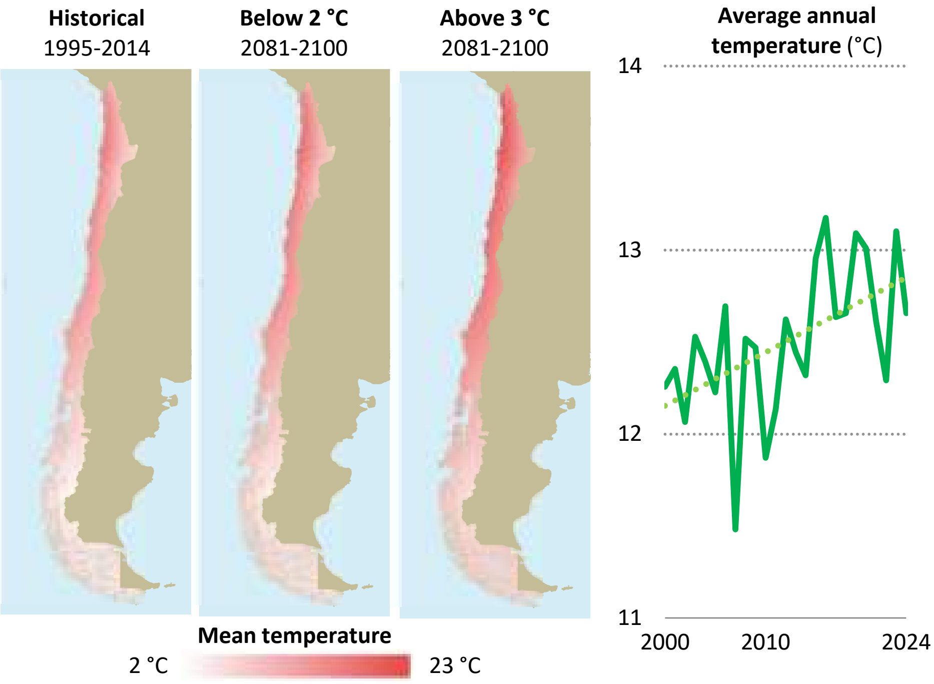
[9] Below 2 °C corresponds to the IPCC SSP1-2.6 scenario (Sixth Assessment Report, [IPCC, 2021]) and is the closest to the APS.

[10] Above 3 °C corresponds to the IPCC SSP 3-7.0 scenario (Sixth Assessment Report).

of warming by mid-century and 3.7 °C of warming by the end of the century. In a high-emissions scenario (above 3 °C), the IPCC projects a rise in temperature in the northern region of Arica y Parinacota to 4.98 °C above pre-industrial levels by the end of the century: the southern region of Magallanes y Antarctica Chilena is projected to warm by 2.7 °C over the same period (Figure 4.18).

Figure 4.18 ▷ Evolution of average temperature in Chile and projected impact of climate change



Temperatures are rising steadily across Chile because of climate change, with the northern regions experiencing the most pronounced warming

Source: IEA analysis based on IPCC (2021) interpolated to 0.1 degrees Celsius (°C).

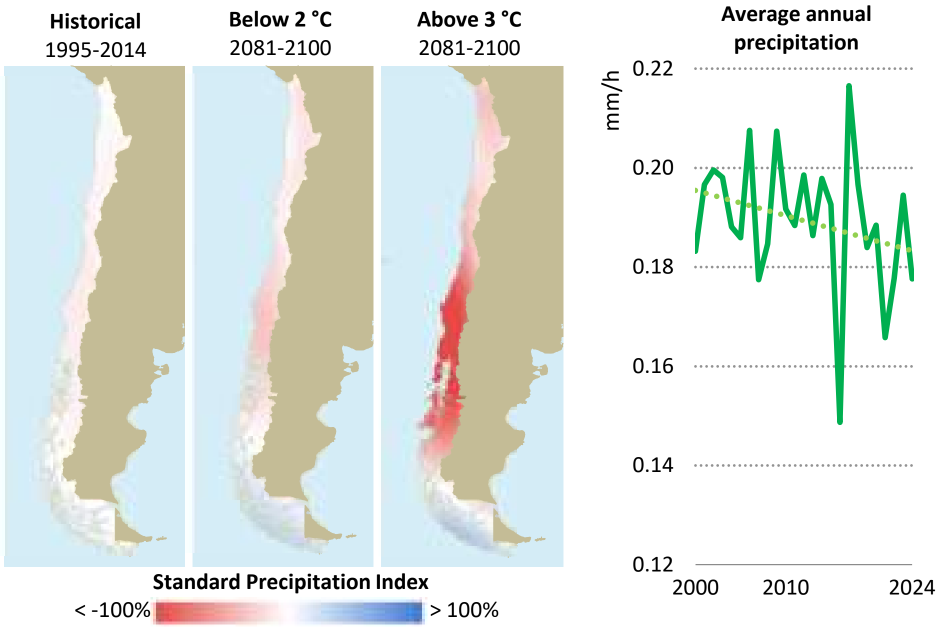
Precipitation

Chile has been suffering from a decline in rainfall since the 1960s. Annual precipitation has fallen at an average rate of 26 millimetres (mm) per decade, with the biggest falls (4-16% per decade) occurring in the southern and central regions. This is shifting south-central Chile toward a semi-arid climate. Stream flows have diminished, and snowpack and glaciers are retreating. In contrast, dry regions in the north, some of which receive less than 70 mm per year of precipitation, have showed a slight increase in rainfall.

Chile experienced an extreme and exceptionally long-lasting drought in the 2010-2015 period. Studies linked about 25% of the precipitation deficit during this drought to climate change (Center for Climate and Resilience Research, 2015). This prolonged drought was damaging for agriculture and ecosystems, and led to more wildfires than usual. Hydro reservoirs for electricity generation and agricultural irrigation reached historical lows: hydroelectric generation dropped 12 percentage points in the 2010-2015 period compared to the previous decade, and Chile had to compensate with fossil fuel generation and imports.

Chile is projected to face a nationwide decline in precipitation by the end of the century, though there are significant regional disparities. Under the low-emissions (below 2 °C) IPCC scenario, average precipitation may fall by 6%, with central regions like Valparaíso and Santiago seeing declines over 14%. In the high-emissions scenario (above 3 °C), average rainfall could drop by 16%, with some regions experiencing reductions exceeding 30% compared to pre-industrial levels (Figure 4.19).

Figure 4.19 ▷ **Evolution of average precipitation in Chile and projected impact of climate change**



IEA. CC BY 4.0.

Precipitation is projected to continue to decline over the coming decades, with central and southern Chile expected to be most affected

Notes: mm/h = millimetre per hour. The Standard Precipitation Index quantifies precipitation anomalies between 2081-2010 relative to the climatological average in the pre-industrial period (1850-1900). Values near -100 represent extremely dry conditions (severe drought), while values near 100 indicate extremely wet conditions.

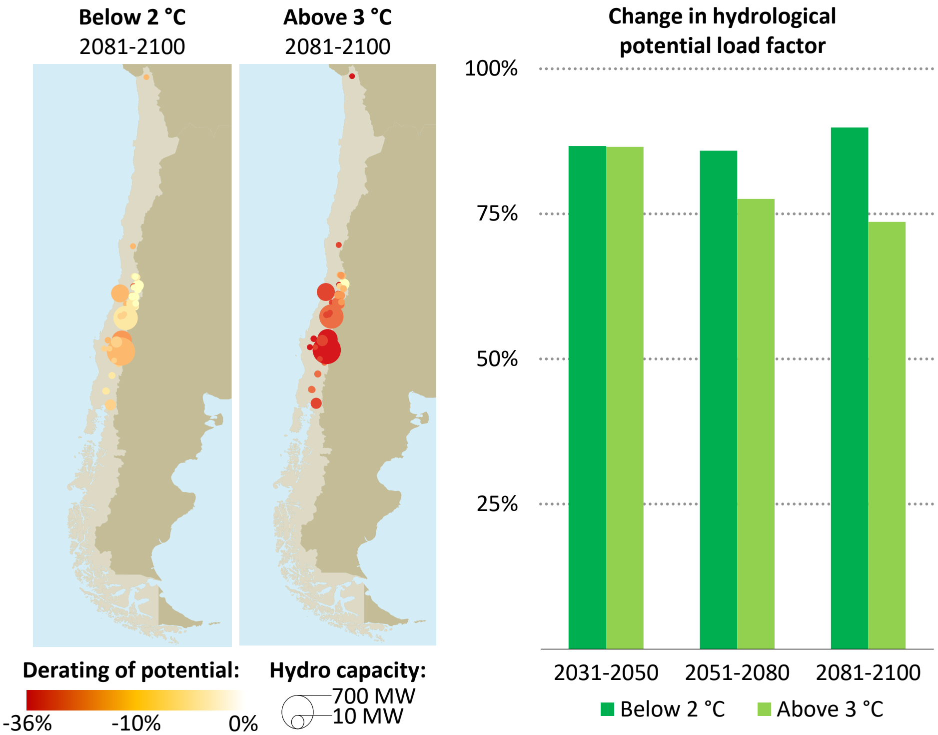
Sources: IEA analysis based on IPCC (2021) interpolated to 0.1 °C.

4.4.3 Impacts of natural hazards and climate change on the power system in Chile

Climate change impacts on hydropower

Hydropower generation in Chile is projected to decline by 2100 due to reduced precipitation and streamflow in key regions such as the Central Andes and Patagonia. Hydropower has always been a cornerstone of Chile's electricity supply, accounting for 27% of the mix on average in the past decade, and it is set to continue to make an important contribution to security of supply (see Chapter 2). A drier climate means less precipitation and snowmelt which translates to lower river flows and reservoir levels, thereby reducing potential hydropower generation.

Figure 4.20 ▷ Change in hydrological potential load factor per hydropower plant under various climate scenarios relative to current levels



IEA. CC BY 4.0.

Nearly all major hydropower plants in Chile are expected to face a drier climate, which could reduce their potential generation by 25% by the end of the century

Notes: Below 2 °C corresponds to the IPCC SSP1-2.6 scenario; Above 3 °C corresponds to the IPCC SSP 3-7.0 scenario.

Sources: IEA analysis based on IPCC (2021) interpolated to 0.1 °C.

Nearly all major hydro plants in Chile are expected to face a drier climate by mid-century, and especially those in central regions. In scenarios that show 3 °C or more of warming globally, at least 50% of installed hydropower capacity is exposed to moderately or significantly drier conditions by the end of the century. If adaptation measures are not put in place, models project that the average hydrological potential load factors could decline by 10% under a low-emissions scenario (below 2 °C) by 2100, and by 25% under a high-emissions (above 3 °C) scenario: the latter is in line with the National Adaptation Plan, which cites an expected 22% decline in hydro capacity factor by 2100 under a high warming scenario.

Hydrological variability is also expected to intensify, bringing wider fluctuations in hydropower availability over time. Although a reduction in hydrological potential affects hydropower output, estimating the absolute decline in generation is challenging because a decrease in inflows does not translate directly into an immediate drop in generation. Reservoir management practices such as seasonal water storage and multi-year balancing allow operators to buffer short-term variations in inflow and to optimise generation.

Climate projections indicate more frequent droughts and possibly more erratic rainfall, e.g. intense downpours in some years, which may cause floods. However, very rainy years do not necessarily offset dry periods, and intense runoff caused by heavy rain can increase spillway use and accelerate silt accumulation, leading to reduced hydro dam performance and higher maintenance needs. High levels of warming could cause year-to-year swings in hydrological potential to widen so that in some years it is only slightly below the historical average, and in others it is extremely low, with a fall of over 40% in capacity in the worst years (Figure 4.20). Increased variability complicates energy planning: the power system needs to be resilient to multi-year droughts as well as sudden wet or dry shocks.

The national Energy Sector Adaptation Plan, currently being updated under the 2022 Climate Change Framework Law, explicitly flags declining water availability for power as a priority issue. Key strategies to mitigate the risk include diversifying the generation mix and reinforcing infrastructure. In particular:

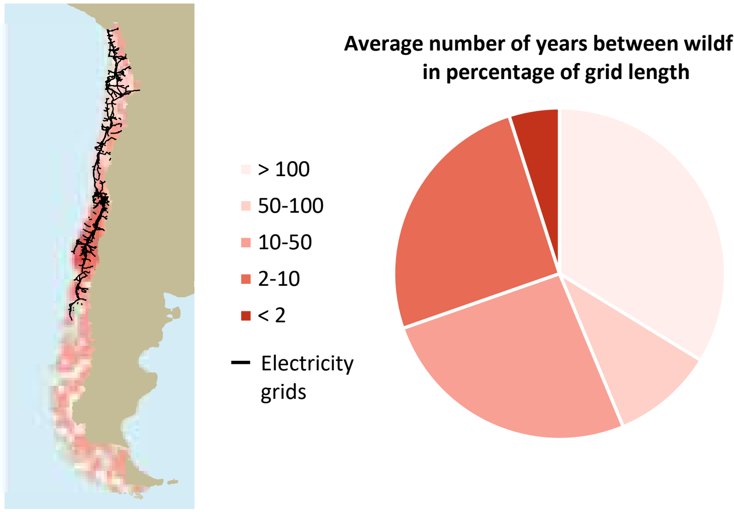
- Solar, wind and storage capacity are expanding rapidly, and are not directly reliant on water.
- Grid enhancements will allow enhanced regional integration both within Chile and with neighbouring countries.
- New cooling technologies such as dry or hybrid cooling are being considered for thermal power plants to reduce their dependence on freshwater.
- Contingency arrangements are being put in place. Some plants have already secured backup water sources or built new infrastructure, e.g. pipelines from more reliable water sources.

Enhanced forecasting of hydrologic inflows, integrated resource planning that accounts for climate uncertainty, and maintaining reserve margins all have an important role to play in risk mitigation.

Wildfire risks

Wildfires are a particular risk in Chile because of its semi-arid climate and fast-growing but resinous vegetation. In 2024, exceptionally hot temperatures linked to El Niño and a decade-long drought led to the burning of more than 43 000 hectares of forest, with substantial human and economic impacts. Recent wildfires have been fiercer than in the past as a result of lack of rainfall, extreme temperature spikes, and highly flammable plantation forests with large areas of pine and eucalyptus. Electricity grids are especially vulnerable to such fires. Grid faults can also trigger wildfires, creating a two-way risk that demands proactive system management and robust operational safeguards.

Figure 4.21 ▷ Chile's electricity grid exposure to wildfire risk, 2024



More than 30% of electricity grids in Chile are located in areas where wildfires are likely to break out at least once every ten years

Notes: The map shows the average annual probability of at least one fire occurring within a 0.5° × 0.5° (nearly 2 500 km^2) grid cell. Probabilities are estimated using a Negative Binomial Generalized Linear Model based on historical fire records, above-ground biomass carbon density, and the Fire Weather Index. Probability classes (<1%, 1–2%, 2–10%, 10–50%, and 50–100%) are expressed as the corresponding average interval between fires in each grid cell: more than 100, 50-100, 10-50, 2-10 and less than two years, respectively. These intervals represent long-term statistical expectations rather than precise predictions for individual years.

Sources: IEA analysis based on: Copernicus Climate Change Service (2019); Giglio et al.(2018); Santoro et al. (2021); OpenSteetMap (2025).

Transmission and distribution lines often span forested or rural areas, and wildfires can easily cause wooden utility poles or outbuildings to catch fire. Wildfires can also cause widespread blackouts by knocking out key power lines or substations, enveloping power plants, restricting access for fuel supply, or damaging towers and depositing soot on insulators, which can cause lines to spark or short circuit. In addition, sparks from electricity lines can themselves start wildfires if the surrounding vegetation and soil are sufficiently dry. In short, wildfires pose a real and direct threat to secure electricity supply.

IEA analysis indicates that over 25% of the grid in Chile is situated in areas where a wildfire is likely to break out every two to ten years on average, and 5% of the grid in areas where wildfires are likely more than once every two years. (Figure 4.21). Under current climate conditions, wildfire risk in Chile is highest in semi-arid zones and in the central Araucanía region. Research indicates that risks will also gradually rise in southern regions as hotter, drier conditions extend into Chile's lake region and Patagonia. One study using climate projections found that the probability of wildfires increases slightly in a low-emissions scenario, and considerably in a high-emissions scenario (Gajardo et al., 2025). The same study noted that grasslands and native forests in southern Chile could become much more fire-prone by mid-to-late century, and that fires could spread into high-biomass areas that rarely burned before.

Following the 2024 fires, Chile established the National Forestry Service (Sernafor) to oversee forest management with a focus on sustainable productivity and wildfire risk mitigation. Sernafor is tasked with co-ordinating the National Plan for Forest Fire Risk Reduction, which currently emphasises suppression strategies rather than prevention. Adaptation measures for wildfire resilience are now becoming a necessity. They include:

- Vegetation management: to ensure adequate clearance, e.g. vegetation buffer zones, around power lines, substations and critical poles. (Vegetation management practices are part of the maintenance costs already embedded in the IEA cost modelling.)
- Fire-hardening infrastructure and undergrounding of power lines: replace wooden poles with steel or concrete in high-risk zones, insulate critical lines and use technology like covered conductors that are less likely to spark. Deploying more sensors on lines can detect faults quickly to isolate sections before they cause fire.
- Improved monitoring and response: use of satellite fire detection and dedicated weather stations to get early warnings of fire outbreaks near key grid assets. Utilities in Chile are starting to employ drones and remote sensing to patrol lines for any damage immediately after a fire to speed restoration.
- Land-use planning: co-ordinate with forestry agencies to manage the landscape and create fire breaks near major transmission corridors.

4.4.4 Enhancing resilience

Policy readiness for climate resilience

Over the past five years, Chile developed its energy policy framework to address climate resilience, particularly in the electricity sector. The 2022 Framework Law on Climate Change and the updated long-term energy plan (PELP) regard resilience as a core objective, mandating sectoral adaptation plans and integrating climate risks into long-term energy planning. Key measures include diversifying electricity generation, expanding energy storage and strengthening grid infrastructure. The 2018 Energy Sector Adaptation Plan identified priority actions, and these are now being updated for a more detailed National Climate Change Adaptation Plan. The disaster risk agency SENAPRED, established in 2021, manages co-ordination and preparedness across sectors.

Although Chile has already done much to incorporate resilience and adaptation into energy policy making, there is scope for more to be done.

- While resilience goals are well-defined in Chile, ensuring consistent adoption and enforcement across all energy actors, particularly small utilities and local governments, remains a challenge.
- Climate risk assessment is not yet systematically embedded in the early stages of energy infrastructure planning and permitting, and thus threatens limiting the long-term effectiveness of resilience measures.
- Although Chile has strong analytical tools standardising their use by public and private stakeholders would improve co-ordination and decision making.
- Sustained investment is necessary to achieve resilience targets such as grid hardening and large-scale storage. This will need to be supported by regulatory incentives and access to climate finance.
- Chile's policy framework allows for updates, and these need to be driven by a systematic cycle of evaluation and adaptation based on new climate data.
- Public participation has been a strength in national planning but even more could be done to expand local-level engagement, especially in vulnerable communities.

Improving electricity grid resilience

Chile's geography and isolation create resilience challenges for its electricity system: its extensive transmission network crosses seismically active terrain, forests and coastal zones, while limited cross-border connections restrict the ability to balance supply during periods of stress. The nationwide power outage of February 2025, which was caused by a failure on a major 500 kilovolt transmission line, fragmented the grid into islands (see Chapter 1, Box 1.1) and underscored that resilience is not only about restoring service after disruption, but about reinforcing planning, operations and infrastructure to prevent failures, contain their spread, and recover swiftly. For Chile, where earthquakes, volcanic eruptions, floods and landslides intersect with high renewables penetration, strengthening resilience requires a comprehensive, layered approach built around three main pillars: prevention, containment and recovery. All actions in these three areas will cost money, and some could be very expensive, which means that their costs and benefits will need to be carefully weighed, and that key priorities need to be established.

Prevention, the first pillar, aims to reduce the probability of an electricity blackout by ensuring that grids adapt to reflect its evolving generation profile. The rapid growth of solar and wind power, particularly in the north, has already saturated existing transmission corridors. Strategic projects such as the Entre Ríos–Lo Aguirre high-voltage direct current line are critical to move surplus solar energy to central demand hubs. Building meshed transmission networks could offer redundancy and flexibility, though their cost means projects must be carefully prioritised. Preventive planning also requires the incorporation of hazard maps into line routing to account for seismic, volcanic and landslide risks. Infrastructure hardening is equally important: substations and towers should be designed or retrofitted to withstand earthquakes and storms, and undergrounding lines in cities can reduce wildfire and storm risks. In flood-prone or coastal areas, elevating infrastructure can reduce vulnerability to tsunamis or inundations.

There are a number of other ways to bolster prevention. Utilities can mitigate the risks posed by forest fires through vegetation management, use of fire-resistant materials, fault detection systems, and the deployment of technologies such as spark prevention units to reduce ignition risks from electrical equipment. As well, microgrids in remote or vulnerable communities can reduce dependence on long, exposed transmission lines. Monitoring the condition of high-voltage assets can be improved through digitalisation and the use of tools such as satellite imagery and artificial intelligence that can flag encroaching vegetation or early signs of structural weakness. With more variable non-synchronous renewables generation, maintaining grid stability becomes more challenging. Solutions include synchronous condensers, static synchronous compensators (STATCOMs), battery storage and smart inverters with grid-forming capabilities. These depend on resilient communication networks and robust cybersecurity to function effectively. As the grid and its resilience needs evolve along with technological advances, adaption of regulation must accelerate accordingly to provide the flexibility and certainty required for timely implementation.

Containment, the second pillar, focuses on limiting the impact of failures once they occur. Plans can be put in place to use distributed resources such as storage and microgrids to maintain critical loads such as hospitals, emergency services or communication networks during main grid outages. Demand-side management and targeted load shedding are additional tools to preserve stability when the power system is under stress. Advanced monitoring systems and real-time communications enhance operator visibility, enabling quick interventions before small faults escalate, and multiple communication pathways increase resilience. Strengthening voltage support in weak grid areas helps to keep the grid stable and operating within safe limits during sudden changes in electricity demand or supply. All these measures can help to contain system failures and disturbances.

Recovery, the third pillar, ensures rapid restoration after an incident. Operator certification programmes and high-fidelity simulations are enhancing human preparedness for crisis response. In high-risk periods, black-start plants, substations and communication hubs will require onsite staff, fallback communication systems and pre-positioned crews to cut restoration times. These measures provide a safety net, ensuring that when failures do occur, the system can be brought back online quickly and securely.

ANNEXES

Data tables

General note to the tables

This annex includes historical and projected data for the Announced Pledges Scenario following five datasets:

- A.1: Chile energy supply.
- A.2: Chile final consumption.
- A.3: Chile electricity sector: gross electricity generation and electrical capacity.
- A.4: Chile CO_2 emissions: carbon dioxide (CO_2) emissions from fossil fuel combustion and industrial processes.
- A.5: Chile economic and activity indicators: selected economic and activity indicators.

The definitions for regions, fuels and sectors are outlined in Annex C.

Abbreviations/acronyms used in the tables include: CAAGR = compound average annual growth rate; CCUS = carbon capture, utilisation and storage; EJ = exajoule; GJ = gigajoule; GW = gigawatt; Mt CO_2 = million tonnes of carbon dioxide; TWh = terawatt-hour. Use of fossil fuels in facilities without CCUS is classified as “unabated”.

Both in the text of this report and in these annex tables, rounding may lead to minor differences between totals and the sum of their individual components. Growth rates are calculated on a compound average annual basis and are marked “n.a.” when the base year is zero or the value exceeds 200%. Nil values are marked “-”.

Data sources

The Global Energy and Climate Model is a very data-intensive model covering the whole global energy system. Detailed references on databases and publications used in the modelling and analysis may be found in Annex E of the *World Energy Outlook 2025*.

The formal base year for this year’s projections is 2023, as this is the most recent year for which a complete picture of energy demand and production is available. However, we have used more recent data wherever available, and we include our 2024 estimates for energy production and demand in this annex. Estimates for the year 2024 are based on the IEA *Global Energy Review 2025* report in which data are derived from a number of sources, including the latest monthly data submissions to the IEA Energy Data Centre, other statistical releases from national administrations, and recent market data from the IEA *Market Report Series* that cover coal, oil, natural gas, renewables and power. Investment estimates include the year 2025 data, based on the IEA *World Energy Investment 2025* report. Historical data for gross power generation capacity (Table A.3) are drawn from the Power Plant Units database and the World Electric Power Plants database both published by S&P Global Market Intelligence; the International Atomic Energy Agency PRIS database; the Global Coal Plant Tracker, and the Global Oil and Gas Plant Tracker databases both published by Global Energy Monitor.

Definitional note: Energy supply and transformation tables

Total energy supply (TES) is equivalent to electricity and heat generation plus the *other energy sector*, excluding electricity, heat and hydrogen, plus total final consumption, excluding electricity, heat and hydrogen. TES does not include ambient heat from heat pumps or electricity trade. *Solar* in TES includes solar PV generation, concentrating solar power (CSP) and final consumption of solar thermal. *Biofuels conversion losses* are the conversion losses to produce biofuels (mainly from modern solid bioenergy) used in the energy sector. *Low-emissions hydrogen production* is merchant low-emissions hydrogen production (excluding onsite production at industrial facilities and refineries), with inputs referring to total fuel inputs and outputs to produce hydrogen. While not itemised separately, *geothermal* and *marine* (tidal and wave) energy are included in the *renewables* category of TES and *electricity and heat sectors*. While not itemised separately, *non-renewable waste* and *other sources* are included in TES.

Definitional note: Energy demand tables

Sectors comprising total final consumption (TFC) include *industry* (energy use and feedstock), *transport* and *buildings* (residential, services and non-specified other). While not itemised separately, *agriculture* and *other non-energy use* are included in TFC. While not itemised separately, non-renewable waste, *solar thermal* and *geothermal* energy are included in *buildings*, *industry* and *TFC*.

Definitional note: Electricity tables

Electricity generation expressed in terawatt-hours (TWh) and installed electrical capacity data expressed in gigawatts (GW) are both provided on a gross basis, i.e. includes own use by the generator. Projected gross electrical capacity is the sum of existing capacity and additions, less retirements. While not itemised separately, *other sources* are included in total electricity generation. Hydrogen and ammonia are fuels that can provide a low-emissions alternative to natural gas- and coal-fired electricity generation – either through co-firing or full conversion of facilities. Blending levels of hydrogen in gas-fired plants and ammonia in coal-fired plants are represented in the scenarios and reported in the tables. The electricity generation outputs in the tables are based on fuel input shares, while the hydrogen and ammonia capacity is derived based on a typical capacity factor.

Definitional note: CO_2 emissions tables

Total CO_2 includes carbon dioxide emissions from the combustion of fossil fuels and non-renewable wastes; from industrial and fuel transformation processes (process emissions); and from flaring and CO_2 removal. CO_2 removal includes: captured and stored emissions from the combustion of bioenergy and renewable wastes; from biofuels production; and from direct air capture.

The first two entries are often reported as bioenergy with carbon capture and storage (BECCS). Note that some of the CO_2 captured from biofuels production and direct air capture is used to produce synthetic fuels, which is not included as CO_2 removal.

Total CO_2 captured includes the carbon dioxide captured from CCUS facilities, such as electricity generation or industry, and atmospheric CO_2 captured through direct air capture, but excludes that captured and used for urea production.

Definitional note: Economic and activity indicators

The emissions intensity expressed in grammes of carbon dioxide per kilowatt-hour (g CO_2 per kWh) is calculated based on electricity-only plants and the electricity component of combined heat and power (CHP) plants.[1] *Primary chemicals* include ethylene, propylene, aromatics, methanol and ammonia. Industrial production data for *aluminium* excludes production based on internally generated scrap. Heavy-duty truck activity includes freight activity of medium freight trucks and heavy freight trucks.

Abbreviations used include: GDP = gross domestic product; GJ = gigajoule; m^2 = square metre; Mt = million tonnes; pkm = passenger-kilometres; PPP = purchasing power parity; tkm = tonne-kilometre.

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[1] To derive the associated electricity-only emissions from CHP plants, we assume that the heat production of a CHP plant is 90% efficient and the remainder of the fuel input is allocated to electricity generation.

Table A.1: Chile energy supply

				Announced Pledges (PJ)			Shares (%)			CAAGR (%) 2024 to:	
	2010	2023	2024	2035	2040	2050	2024	2035	2050	2035	2050
Total energy supply	**1 280**	**1 684**	**1 679**	**2 026**	**2 111**	**2 443**	**100**	**100**	**100**	**1.7**	**1.5**
Renewables	287	583	609	1 219	1 526	2 138	36	60	88	6.5	4.9
Solar	-	69	78	375	542	904	5	19	37	15	9.9
Wind	1	34	38	268	356	512	2	13	21	19	11
Hydro	78	85	94	90	90	90	6	4	4	-0.4	-0.2
Modern solid bioenergy	206	367	370	367	352	334	22	18	14	-0.1	-0.4
Modern liquid bioenergy	-	-	-	4	5	7	-	0	0	n.a.	n.a.
Modern gaseous bioenergy	1	15	15	20	18	30	1	1	1	2.6	2.7
Traditional use of biomass	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Nuclear	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas	178	246	227	202	176	151	14	10	6	-1.1	-1.6
Unabated	154	216	194	164	137	113	12	8	5	-1.5	-2.1
With CCUS	-	-	-	-	-	1	-	-	0	n.a.	n.a.
Oil	628	719	724	592	403	149	43	29	6	-1.8	-5.9
Non-energy use	13	41	40	41	36	24	2	2	1	0.2	-1.9
Coal	187	134	120	13	5	4	7	1	0	-18	-12
Unabated	187	134	120	12	5	3	7	1	0	-19	-13
With CCUS	-	-	-	-	-	1	-	-	0	n.a.	n.a.
Electricity and heat sectors	**403**	**666**	**645**	**1 094**	**1 364**	**1 949**	**100**	**100**	**100**	**4.9**	**4.3**
Renewables	95	399	419	1 012	1 307	1 893	65	93	97	8.3	6.0
Solar PV	-	66	74	364	503	817	11	33	42	16	9.7
Wind	1	34	38	268	356	512	6	24	26	19	11
Hydro	78	85	94	90	90	90	15	8	5	-0.4	-0.2
Bioenergy	15	201	199	205	196	196	31	19	10	0.3	-0.1
Hydrogen	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Ammonia	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Nuclear	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Unabated natural gas	73	132	105	76	56	55	16	7	3	-2.9	-2.5
Natural gas with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Oil	73	16	13	-	-	-	2	-	-	n.a.	n.a.
Unabated coal	161	119	109	6	-	-	17	1	-	-23	n.a.
Coal with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Other energy sector	**88**	**43**	**53**	**496**	**747**	**1 298**	**100**	**100**	**100**	**23**	**13**
Biofuels conversion losses	-	3	3	7	9	9	100	100	100	8.0	4.3
Low-emissions hydrogen (offsite)											
Production inputs	-	-	-	239	371	667	100	100	100	n.a.	n.a.
Production outputs	-	-	-	168	265	494	100	100	100	n.a.	n.a.
For hydrogen-based fuels	-	-	-	163	250	442	-	97	89	n.a.	n.a.

Table A.2: Chile final consumption

				Announced Pledges (PJ)			Shares (%)			CAAGR (%) 2024 to:	
	2010	2023	2024	2035	2040	2050	2024	2035	2050	2035	2050
Total final consumption	**1 010**	**1 301**	**1 310**	**1 312**	**1 206**	**1 070**	**100**	**100**	**100**	**0.0**	**-0.8**
Electricity	197	304	306	409	485	589	23	31	55	2.7	2.6
Liquid fuels	507	693	690	591	412	163	53	45	15	-1.4	-5.4
Biofuels	-	-	-	4	5	7	-	0	1	n.a.	n.a.
Ammonia	-	-	-	-	1	1	-	-	0	n.a.	n.a.
Synthetic oil	-	-	-	-	2	4	-	-	0	n.a.	n.a.
Oil	507	693	690	586	405	152	53	45	14	-1.5	-5.7
Gaseous fuels	99	104	111	124	128	147	8	9	14	1.0	1.1
Biomethane	1	1	2	7	10	22	0	1	2	12	9.7
Hydrogen	-	-	-	4	13	45	-	0	4	n.a.	n.a.
Synthetic methane	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas	99	102	109	112	105	79	8	9	7	0.2	-1.2
Solid fuels	206	197	198	176	161	139	15	13	13	-1.1	-1.4
Solid bioenergy	179	182	188	171	156	135	14	13	13	-0.9	-1.3
Coal	27	14	9	5	5	3	1	0	0	-5.2	-4.1
Heat	-	-	-	1	2	3	-	0	0	n.a.	n.a.
Industry	**400**	**498**	**494**	**515**	**514**	**497**	**100**	**100**	**100**	**0.4**	**0.0**
Electricity	129	178	179	221	236	249	36	43	50	1.9	1.3
Liquid fuels	128	168	162	121	97	53	33	23	11	-2.6	-4.2
Oil	128	168	162	121	97	53	33	23	11	-2.6	-4.2
Gaseous fuels	71	60	66	72	74	85	13	14	17	0.8	1.0
Biomethane	-	1	1	3	5	10	0	1	2	11	9.3
Hydrogen	-	-	-	3	10	33	-	1	7	n.a.	n.a.
Unabated natural gas	52	40	43	38	31	16	9	7	3	-1.1	-3.7
Natural gas with CCUS	-	-	-	-	-	1	-	-	0	n.a.	n.a.
Solid fuels	72	92	87	99	101	102	18	19	21	1.2	0.6
Modern solid bioenergy	46	77	77	93	96	98	16	18	20	1.7	0.9
Unabated coal	26	14	9	5	4	2	2	1	0	-5.2	-5.6
Coal with CCUS	-	-	-	-	-	1	-	-	0	n.a.	n.a.
Heat	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Chemicals	36	37	41	53	54	54	8	10	11	2.4	1.1
Iron and steel	16	14	11	7	7	8	2	1	2	-4.0	-1.2
Cement	12	11	11	11	11	11	2	2	2	0.0	0.0
Aluminium	-	-	-	-	-	-	-	-	-	n.a.	n.a.

Table A.2: Chile final consumption (continued)

				Announced Pledges (PJ)			Shares (%)			CAAGR (%) 2024 to:	
	2010	2023	2024	2035	2040	2050	2024	2035	2050	2035	2050
Transport	**299**	**400**	**405**	**394**	**310**	**216**	**100**	**100**	**100**	**-0.3**	**-2.4**
Electricity	2	5	5	36	80	141	1	9	65	20	14
Liquid fuels	297	394	400	357	226	64	99	91	30	-1.0	-6.8
Biofuels	-	-	-	3	4	5	-	1	2	n.a.	n.a.
Oil	297	394	400	353	221	54	99	90	25	-1.1	-7.4
Gaseous fuels	1	1	1	1	3	12	0	0	6	0.0	10
Biomethane	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Hydrogen	-	-	-	1	3	12	-	0	6	n.a.	n.a.
Natural gas	1	1	1	-	-	-	0	-	-	n.a.	n.a.
Road	263	360	365	352	267	172	90	89	80	-0.3	-2.9
Passenger cars	117	196	199	210	155	100	49	53	46	0.5	-2.6
Heavy-duty trucks	59	52	52	58	56	42	13	15	19	1.0	-0.8
Buildings	**281**	**323**	**331**	**322**	**308**	**297**	**100**	**100**	**100**	**-0.3**	**-0.4**
Electricity	66	110	111	141	158	189	34	44	64	2.2	2.1
Liquid fuels	58	74	73	58	39	12	22	18	4	-2.1	-6.7
Biofuels	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Oil	58	74	73	58	39	12	22	18	4	-2.1	-6.7
Gaseous fuels	22	30	33	38	39	39	10	12	13	1.3	0.6
Biomethane	-	1	1	3	5	12	0	1	4	11	10
Hydrogen	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas	21	29	31	34	33	25	9	11	8	0.8	-0.8
Solid fuels	134	105	110	77	59	36	33	24	12	-3.2	-4.2
Modern solid bioenergy	134	105	110	77	59	36	33	24	12	-3.2	-4.2
Traditional use of biomass	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Coal	1	-	-	-	-	-	-	-	-	n.a.	n.a.
Heat	-	-	-	1	2	3	-	0	1	n.a.	n.a.
Residential	223	241	248	221	201	179	75	69	60	-1.0	-1.2
Services	57	83	83	101	107	118	25	31	40	1.8	1.4

Table A.3: Chile electricity sector

				Announced Pledges (TWh)			Shares (%)			CAAGR (%) 2024 to:	
	2010	2023	2024	2035	2040	2050	2024	2035	2050	2035	2050
Total generation	**60**	**90**	**91**	**221**	**285**	**423**	**100**	**100**	**100**	**8.4**	**6.1**
Renewables	24	57	63	210	278	416	69	95	98	12	7.5
Solar PV	-	18	21	101	140	227	23	46	54	16	9.7
Wind	0	9	10	74	99	142	11	34	34	20	11
Hydro	22	24	26	25	25	25	29	11	6	-0.4	-0.2
Bioenergy	2	6	6	7	8	9	6	3	2	2.0	1.9
of which BECCS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
CSP	-	0	0	-	3	7	0	-	2	n.a.	17
Geothermal	-	0	0	2	4	6	0	1	1	18	11
Marine	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Nuclear	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Hydrogen and ammonia	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Fossil fuels with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Coal with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Unabated fossil fuels	36	33	28	11	7	7	31	5	2	-8.3	-5.2
Coal	17	15	13	1	-	-	15	0	-	-23	n.a.
Natural gas	11	17	13	10	7	7	15	4	2	-2.6	-2.4
Oil	8	2	1	-	-	-	1	-	-	n.a.	n.a.

				Announced Pledges (GW)			Shares (%)			CAAGR (%) 2024 to:	
	2010	2023	2024	2035	2040	2050	2024	2035	2050	2035	2050
Total capacity	**16**	**36**	**40**	**107**	**134**	**191**	**100**	**100**	**100**	**9.4**	**6.2**
Renewables	6	24	27	89	114	167	67	83	87	12	7.3
Solar PV	-	11	13	49	63	100	34	46	52	12	8.0
Wind	0	5	5	30	39	52	12	28	27	18	9.6
Hydro	5	8	8	8	8	8	19	7	4	0.4	0.2
Bioenergy	0	1	1	1	1	1	1	1	1	4.9	3.6
of which BECCS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
CSP	-	0	0	1	3	5	0	1	2	24	16
Geothermal	-	0	0	0	1	1	0	0	0	15	9.4
Marine	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Nuclear	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Hydrogen and ammonia	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Fossil fuels with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Coal with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Unabated fossil fuels	11	12	12	10	9	9	31	9	4	-2.2	-1.4
Coal	3	4	4	1	-	-	10	1	-	-14	n.a.
Natural gas	4	5	5	5	5	5	12	5	3	1.0	0.6
Oil	4	4	4	4	4	3	10	4	2	-0.1	-0.7
Battery storage	-	0	1	8	11	16	2	8	8	24	12

Table A.4: Chile CO₂ emissions

				Announced Pledges (Mt CO_2)			CAAGR (%) 2024 to:	
	2010	**2023**	**2024**	**2035**	**2040**	**2050**	**2035**	**2050**
Total CO_2*	**72**	**76**	**72**	**51**	**36**	**16**	**-3.1**	**-5.6**
Combustion activities (+)	**69**	**73**	**71**	**50**	**35**	**16**	**-3.1**	**-5.6**
Coal	18	12	11	1	0	0	-20	-16
Oil	42	49	48	40	27	9	-1.8	-6.1
Natural gas	9	12	11	9	8	6	-1.6	-2.1
Bioenergy and waste	0	0	0	0	- 0	- 0	-6.9	n.a.
Other removals (-)**	**-**	**-**	**-**	**-**	**-**	**-**	**n.a.**	**n.a.**
Biofuels production	-	-	-	-	-	-	n.a.	n.a.
Direct air capture	-	-	-	-	-	-	n.a.	n.a.
Electricity and heat sectors	**25**	**20**	**17**	**5**	**3**	**3**	**-11**	**-6.4**
Coal	15	11	10	1	-	-	-23	n.a.
Oil	6	1	1	-	-	-	n.a.	n.a.
Natural gas	4	7	6	4	3	3	-2.9	-2.4
Bioenergy and waste	-	-	-	-	-	-	n.a.	n.a.
Other energy sector**	**2**	**1**	**1**	**1**	**1**	**1**	**-2.0**	**-1.1**
Final consumption**	**45**	**54**	**54**	**45**	**32**	**12**	**-1.6**	**-5.6**
Coal	2	1	1	0	0	0	-5.9	-6.5
Oil	36	47	47	39	26	9	-1.6	-6.1
Natural gas	4	4	4	4	4	2	-0.3	-2.3
Bioenergy and waste	0	0	0	0	- 0	- 0	-6.9	n.a.
Industry**	17	18	17	13	10	5	-2.4	-4.3
Chemicals**	1	1	1	1	1	1	0.2	-2.2
Iron and steel**	1	1	1	0	0	0	-5.5	-5.8
Cement**	2	2	2	2	1	1	-2.0	-4.7
Aluminium**	-	-	-	-	-	-	n.a.	n.a.
Transport	21	28	29	25	16	4	-1.1	-7.4
Road	19	26	26	23	13	2	-1.2	-9.7
Passenger cars	8	14	14	14	7	0	-0.4	-13
Heavy-duty trucks	4	4	4	4	4	1	0.6	-4.6
Buildings	5	7	7	6	4	2	-1.3	-4.1
Residential	3	4	4	4	3	1	-1.3	-4.6
Services	2	2	2	2	2	1	-1.3	-3.3
Total CO_2 removals**	**-**	**-**	**-**	**0**	**0**	**0**	**n.a.**	**n.a.**
Total CO_2 captured**	**-**	**-**	**-**	**3**	**6**	**11**	**n.a.**	**n.a.**

*Includes industrial process and flaring emissions.

**Includes industrial process emissions.

Table A.5: Chile economic and activity indicators

				Announced Pledges			CAAGR (%) 2024 to:	
	2010	2023	2024	2035	2040	2050	2035	2050
Indicators								
Population (million)	17.1	20.0	20.1	20.8	20.9	20.6	0.3	0.1
GDP (USD 2024 billion, PPP)	471	661	678	847	917	1 053	2.0	1.7
GDP per capita (USD 2024, PPP)	27 600	33 092	33 785	40 801	43 982	51 032	1.7	1.6
TES/GDP (GJ per USD 1 000, PPP)	2.7	2.6	2.5	2.4	2.3	2.3	-0.3	-0.3
TFC/GDP (GJ per USD 1 000, PPP)	2.1	2.0	1.9	1.5	1.3	1.0	-2.0	-2.4
CO_2 intensity of electricity generation (g CO_2 per kWh)	415	221	189	22	11	7	-18	-12
Industrial production (Mt)								
Primary chemicals	1.0	1.1	1.2	1.6	1.6	1.7	2.7	1.4
Steel	1.0	1.2	0.8	0.6	0.7	0.9	-2.4	0.5
Cement	3.9	3.6	3.7	3.7	3.6	3.6	-0.0	-0.1
Aluminium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
Transport								
Passenger cars (billion pkm)	58	113	116	187	220	259	4.5	3.1
Heavy-duty trucks (billion tkm)	54	50	50	64	69	79	2.3	1.8
Buildings								
Households (million)	5.1	7.0	7.2	7.9	8.2	8.6	0.9	0.7
Residential floor area (million m^2)	401	574	584	679	712	762	1.4	1.0
Services floor area (million m^2)	91	137	140	173	188	215	2.0	1.7

Policies

Policy actions taken by governments are key inputs to this analysis and report: *Chile 2050 Energy Transition Roadmap*. An overview of the policies, measures and targets considered in the various scenarios is included in Tables B.1 to B.6. The tables do not include all policies and measures but rather highlight the latest, prominent policies shaping global and regional energy demand today. A more complete policy dataset can be accessed through the publicly available IEA Global Energy Policies Hub[1].

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[1] https://www.iea.org/data-and-statistics/data-tools/global-energy-policies-hub

Table B.1 ⊳ Selected electricity sector policies in Chile

Policy	Publication year
• Updated Nationally Determined Contribution (NDC): reaffirms target of 80% minimum of national electricity generation to come from renewable sources by 2030.	2025
• Decarbonisation Plan: 2030-oriented implementation plan to accelerate coal phase out while preserving energy security and resilience.	2025
• Law 21.721 on Energy Transition: provisions to fast-track ”necessary and urgent” transmission projects; generation companies authorised to propose and finance transmission expansion projects themselves; financial and legal incentives to avoid delays in transmission projects.	2024
• Green tax on fixed sources emitting more than 100 tonnes of particulate matter (t PM) per year or 25 000 tonnes of carbon dioxide per year (Mt CO_2/year); increase planned for fixed emissions sources in the electricity sector by 2035.	2023
• Updated National Energy Policy targets: • National electricity generation to be 100% from zero emissions sources by 2050; and 80% of it to come from renewable sources by 2030. • National Electric System to integrate 6 000 megawatts (MW) in storage, e.g. batteries, hydraulic pumping, Compressed-air energy storage and Liquid air energy storage by 2050, and 2 000 MW by 2030.	2022
• Law 21.505 on Promoting Electricity Storage and Electromobility: remuneration incentives for stand-alone storage systems and storage systems paired with generation.	2022
• Public/private agreement on coal phase out and/ or reconversion: phase out of coal-fired power plants by 2040; with intermediate targets for plant closures by 2024.	2019

Table B.2 ⊳ Selected low-emissions hydrogen policies in Chile

Policy	Publication year
• National Hydrogen Strategy targets (update in progress): • Electrolysis capacity (operating and under development) to reach 5 gigawatts (GW) by 2025 and 25 GW by 2030. • Export value of hydrogen and derivatives to reach USD 2.5 billion/year by 2030.	2020
• Technological Programme on Local Manufacturing Capabilities of Enabling Components for the Hydrogen Industry in Chile, and Use and Adoption of Hydrogen in Chilean Industry: project-based financial support provided by the Production Development Corporation (Corporación de Fomento de la Producción de Chile) for up to 60% of project costs.	2023-2025
• Green Hydrogen Action Plan and CORFO Green Hydrogen Facility: provision of financial support of up to USD 10 million for projects establishing domestic electrolyser manufacturing capacity.	2024

Table B.3 ⊳ Selected industry sector policies in Chile

Policy	Publication year
• Updated NDC: reduce domestic company direct emissions to less than 20% of national emissions by 2030, and increase voluntary greenhouse gas (GHG) reporting.	2025
• Framework Law on Sectoral Authorizations – reduce permitting delivery time by a third.	2025
• Green tax on fixed sources emitting more than 100 (t PM)/year or 25 000 t CO_2/year.	2023
• National Lithium Strategy: Special provisions incorporated in lithium contracts ensuring a portion of production is sold at a preferential price for specific use by refining and battery industries based in Chile.	2023
• National Mining Policy 2050: mining sector to achieve carbon neutrality and to reduce its share of national water use to under 5% by 2040.	2022
• National Mining Policy 2050: increase copper production to 28% of global production by 2050; increase lithium carbonate production to 380 kilotonnes/year by 2030.	2022
• Sectoral Climate Change plan for the Mining Sector: includes measures to promote the decarbonisation of mining, including adaptation strategies for climate resilience.	2024
• Law 21.368: ban on sale of single-use plastic products in the food sector, and of plastic bottles, by 2026.	2022
• Law 21.305 on Energy Efficiency: energy management systems to become mandatory for large energy consumers (>50 Teracalories/year) by 2023	2021

Table B.4 ⊳ Selected transport sector policies in Chile

Policy	Publication year
• Updated NDC: peak GHG emissions in the transport sector by 2030.	2025
• Law 21.505 promoting electricity storage and electromobility: temporary tax exemption scheme for electric and hybrid vehicles manufactured from 2021 forward, in effect from 2022 up to 2030.	2022
• National Electromobility Strategy targets (Resolution N°8/2022): 100% of new light-duty and medium-duty vehicles and new urban public transport vehicles to be zero emissions by 2035; 100% of inter-regional bus and freight vehicle sales to be zero emissions vehicles by 2045.	2021
• Law 21.305 on Energy Efficiency: gradual improvement in light-duty vehicles efficiency to 28.9 kilometres per litre by 2030.	2021
• Sustainable Aviation Fuels (SAF) Roadmap: SAF to meet half of aviation fuel consumption demand (national and international flights) by 2050 (roadmap to be updated in 2027).	2024
• Green tax on the purchase of new cars based on urban performance fuel consumption rating, nitrogen oxides emissions and vehicle price.	2017
• Regional subsidies for the replacement of internal combustion engine taxis by electric vehicles.	2021
• Mobility Network (Red Movilidad) Fleet Renovation Plan: aims for 68% of Santiago's urban bus fleet to be electric by March 2026.	2025

Table B.5 ⊳ Selected buildings sector policies in Chile

Policy	Publication year
• Updated NDC: by 2035, recycle 40% of waste generated annually by the construction sector.	2025
• Updated NDC: measures to mitigate hydrofluorocarbon (HFC) emissions: pilot public procurement projects for lowest climate impact refrigeration and air conditioning equipment to be implemented by 2027; regulations on HFC emissions from large refrigerated or air-conditioned areas to be set out by 2028; regulations and related incentives for replacing conventional HFCs in priority sectors (transport, domestic refrigeration) to be implemented by 2030.	2025
• General Ordinance of Urbanism and Construction: updated thermal regulations incorporating minimum thermal performance requirements for education and healthcare buildings.	2024
• Updated National Energy Policy targets: • 100% of wood-based heating in urban centres to meet low-moisture standards by 2030. • 100% low-emissions heating and cooking in households by 2040. • 100% of new buildings to be net zero energy use by 2050. • 500 000 users to be connected to district heating by 2050.	2022
• National Energy Efficiency Plan 2022-2026: minimum energy performance standards and/or labels updated for washing machines, air conditioners, and introduced for televisions, dryers, electric ovens, microwave ovens and dishwashers.	2022
• Law 21.305 on Energy Efficiency: establishes an obligation for new buildings to get an energy performance certificate to obtain final occupancy permits. The certificate also needs to be included in all sales advertising by companies.	2021
• National Cooling and Heating Strategy targets: • 80% of energy used for cooling or heating in all economic sectors to come from sustainable sources by 2050. • GHG emissions linked to heating and cooling to be reduced by 65% by 2050 from 2019 levels.	2021
• Law 21.711 Geothermal Concessions Law: simplifies requirements for shallow geothermal projects (<400 metres, average temperature up to 90 °C).	2024
• Heater Replacement Program: financial support distributed through regional authorities for households upgrading heaters.	2016

Table B.6 ▹ Selected Just Transition policies in Chile

Policy	Publication year
• Updated National Energy Policy targets: • 100% of wood-based heating in urban centres to meet low-moisture standards by 2030. • 100% low-emissions heating and cooking in households by 2040. • Average power outage to be limited to four hours per year in any region by 2035 and to one hour per year by 2050.	2022
• Electricity consumer subsidy reform: extends temporary consumer support to 2027; targets the 40% most vulnerable households, small and medium enterprises and rural service providers.	2024
• 2025-2035 National Strategy for a Just Transition in the Energy Sector: measures to support workforce retraining, ecosystem restoration and protection, community well-being and technology innovation to enable sustainable production.	2025
• Law 21.499 on Solid Biofuels: makes certification mandatory for solid biomass-based fuels.	2022
• Stabilization Mechanism for Fuel Prices: subsidises and caps consumer price of vehicle fuels: diesel, gasoline ,liquefied petroleum gas and compressed natural gas.	2014
• Energy Access Fund: aims to facilitate electricity access in rural, isolated and/or vulnerable regions. Finances small-scale energy systems essentially based on renewable sources, e.g. photovoltaics and solar thermal.	2014
• Programme for Social and Rural Access to Energy: supports projects to increase rural electrification, develop the use of conventional and non-conventional renewable energy sources in stand-alone electricity generation systems, and increase the energy performance of public lighting.	2008
• ”Road to Light” Programme: aims to boost existing initiatives and projects to bring electricity access to the 30 000 households not benefiting from it in rural and isolated areas, identified through an updated mapping exercise.	2019
• Better Household Programme: household-oriented subsidy scheme to retrofit existing homes and community facilities, targeting low-income households/areas.	2019

Definitions

This annex provides general information on terminology used throughout this report including: units and general conversion factors; definitions of fuels, processes and sectors; regional and country groupings; and abbreviations and acronyms.

Units

Area	km^2	square kilometre
	Mha	million hectares
Distance	µm	micrometre (1 metre x 10^{-6})
	km	kilometre
Emissions	ppm	parts per million (by volume)
	t CO_2	tonnes of carbon dioxide
	Gt CO_2-eq	gigatonnes of carbon-dioxide equivalent (using 100-year global warming potentials for different greenhouse gases)
	kg CO_2-eq	kilogrammes of carbon-dioxide equivalent
	g CO_2/km	grammes of carbon dioxide per kilometre
	g CO_2/kWh	grammes of carbon dioxide per kilowatt-hour
	kg CO_2/kWh	kilogrammes of carbon dioxide per kilowatt-hour
	USD/t CO_2	US dollars per tonne of carbon dioxide
Energy	MJ	megajoule (1 joule x 10^6)
	GJ	gigajoule (1 joule x 10^9)
	TJ	terajoule (1 joule x 10^{12})
	PJ	petajoule (1 joule x 10^{15})
	EJ	exajoule (1 joule x 10^{18})
	W	watt (1 joule per second)
	kW	kilowatt (1 watt x 10^3)
	MW	megawatt (1 watt x 10^6)
	GW	gigawatt (1 watt x 10^9)
	TW	terawatt (1 watt x 10^{12})
	kWh	kilowatt-hour
	MWh	megawatt-hour
	GWh	gigawatt-hour
	TWh	terawatt-hour
	MBtu	million British thermal units
Energy density	Wh/kg	watt hours per kilogramme
Energy equivalence	kboe/d	thousand barrels of oil equivalent per day
	Mtoe	million tonnes of oil equivalent
	bcme	billion cubic metres of natural gas equivalent
	Mtce	million tonnes of coal equivalent (equals 0.7 Mtoe)

Mass	kg	kilogramme
	t	tonne (1 tonne = 1 000 kg)
	kt	kilotonne (1 tonne x 10^3)
	Mt	million tonnes (1 tonne x 10^6)
	Gt	gigatonne (1 tonne x 10^9)
Monetary	USD million	1 US dollar x 10^6
	USD billion	1 US dollar x 10^9
	USD trillion	1 US dollar x 10^{12}
Volumetric	bcm	billion cubic metres
	barrel	one barrel of crude oil
	kb/d	thousand barrels per day
	mb/d	million barrels per day

General conversion factors for energy

		Multiplier to convert to:					
		EJ	**Mtoe**	**MBtu**	**bcme**	**Mtce**	**TWh**
Convert from:	**EJ**	1	23.88	9.478 x 10^8	27.78	34.12	277.8
	Mtoe	0.04187	1	3.968 x 10^7	1.163	1.429	11.63
	MBtu	1.0551 x 10^{-9}	2.520 x 10^{-8}	1	2.931 x 10^{-8}	3.60 x 10^{-8}	2.931 x 10^{-7}
	bcme	0.036	0.860	3.412 x 10^7	1	1.228	10
	Mtce	0.02931	0.700	2.778 x 10^7	0.8141	1	8.141
	TWh	0.0036	0.086	3 412 x 10^6	0.1	0.1228	1

Note: There is no generally accepted definition of barrel of oil equivalent (boe); typically the conversion factors used vary from 7.15 to 7.40 boe per tonne of oil equivalent. Conversions to and from billion cubic metres of natural gas equivalent (bcme) are given as representative multipliers but may differ from the average values obtained by converting natural gas volumes between International Energy Agency (IEA) balances due to the use of country-specific energy densities. Lower heating values (LHV) are used throughout.

Currency conversion

Exchange rates *(2024 annual average)*	**1 US dollar (USD) equals:**
Chilean Peso	943.57

Source: World Bank Data: Official exchange rate (Local Currency Units per USD, period average), https://data.worldbank.org/indicator/PA.NUS.FCRF, accessed September 2025.

Definitions

Agriculture: Includes all energy used on farms, in forestry and for fishing.

Agriculture, forestry and other land use (AFOLU)**:** A sector included in greenhouse gas accounting frameworks which encompasses managed ecosystems. AFOLU emissions include greenhouse gas emissions from agriculture, land use, land-use change and forestry.

Ammonia (NH_3): A compound of nitrogen and hydrogen (NH_3) that is an industrially produced input to fertiliser manufacturing, resulting in substantial carbon dioxide (CO_2) emissions from the use of fossil fuel inputs to generate the input hydrogen. With properties similar to liquefied petroleum gas, ammonia can also be used directly as a fuel in direct combustion processes, as well as in fuel cells, and can be cracked to release its hydrogen content. As it can be made from low-emissions hydrogen, ammonia has the potential to be a low-emissions fuel if the production process, including nitrogen separation, is powered by low-emissions energy. Produced in such a way, ammonia is considered a low-emissions hydrogen-based liquid fuel.

Aviation: This transport mode includes both domestic and international flights and their use of aviation fuels. Domestic aviation covers flights that depart and land in the same country; flights for military purposes are included. International aviation includes flights that land in a country other than the departure location.

Back-up generation capacity: Households and businesses connected to a main power grid may also have a source of back-up power generation capacity that, in the event of disruption, can provide electricity. Back-up generators are typically fuelled with diesel or gasoline. Capacity can be as little as a few hundred watts. Such capacity is distinct from mini-grid and off-grid systems that are not connected to a main power grid.

Battery storage: Energy storage technology that uses reversible chemical reactions to absorb, store and release electricity on demand.

Biodiesel: Diesel-equivalent fuel made from the transesterification of vegetable oils and animal fats, hydrogenated vegetable oil, thermal processes such as gasification and fermentation.

Bioenergy: Energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas. It includes solid bioenergy, liquid biofuels and biogases. Excludes hydrogen produced from bioenergy, including via electricity from a biomass-fired plant, as well as synthetic fuels made with CO_2 feedstock from a biomass source**.**

Biogas: A mixture of methane, CO_2 and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment. It includes landfill gas and sewage sludge gas, and it can be upgraded by removing non-methane constituents, principally CO_2.

Biogases: Include both biogas and biomethane.

Biogasoline: Includes all liquid biofuels used as a substitute for gasoline.

Biogenic CO_2 emissions: CO_2 emissions directly resulting from the combustion, decomposition, or processing of biologically based materials. Biogenic CO_2 is generated in several industrial processes, including: CO_2 released during ethanol fermentation (where ethanol and CO_2 are produced in nearly equal amounts), CO_2 from the anaerobic digestion of organic matter to biogas (a mixture of methane and CO_2), and CO_2 in the flue gas from biomass combustion, such as in the pulp and paper industry or biomass-fired power plants.

Biojet kerosene: Kerosene substitute produced from biomass. It includes conversion routes such as hydro-processed esters and fatty acids (HEFA) and biomass gasification with Fischer-Tropsch. It excludes synthetic kerosene produced from biogenic carbon dioxide.

Biomethane: Biomethane is a near-pure source of methane produced either by "upgrading" biogas (a process that removes any carbon dioxide and other contaminants present in the biogas) or through the gasification of solid biomass followed by methanation. It is also known as renewable natural gas.

Buildings: The buildings sector includes energy used in residential and services buildings. Services buildings include commercial and institutional buildings and other non-specified buildings. Building energy use includes space heating and cooling, water heating, lighting, appliances and cooking equipment. It also includes energy used by data centres and desalination plants.

Bunkers: Include both international marine bunker fuels and international aviation bunker fuels.

Carbon capture, utilisation and storage (CCUS): The process of capturing carbon dioxide emissions from fuel combustion, industrial processes or directly from the atmosphere. Captured CO_2 emissions can be stored in underground geological formations, onshore or offshore, or used as an input or feedstock in manufacturing.

Carbon dioxide (CO_2): A gas consisting of one part carbon and two parts oxygen. It is an important greenhouse (heat-trapping) gas.

Chemical feedstock: Physical energy products used as raw materials to produce chemical products, typically in the petrochemicals sector. Examples are crude oil-based ethane or naphtha to produce ethylene in steam crackers.

Clean cooking systems: Cooking solutions that release less harmful pollutants, are more efficient and environmentally sustainable than traditional cooking options that make use of solid biomass, coal or kerosene. It refers to improved cook stoves, biogas/biodigester systems, electric stoves, liquefied petroleum gas, natural gas or ethanol stoves.

Clean energy: In *power*, clean energy includes: renewable energy sources; nuclear power; fossil fuels fitted with carbon capture, utilisation and storage (CCUS); hydrogen and ammonia; battery storage; and electricity grids. In *efficiency*, clean energy includes energy efficiency in buildings, industry and transport, excluding domestic navigation. In *end-use applications*, clean energy includes: direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; CCUS in industry and direct air capture. In *fuel supply*, clean energy includes low-emissions fuels, direct air capture and measures to reduce the emissions intensity of fossil fuel production.

Coal: Consists of both primary coal, i.e. lignite, coking and steam coal, and derived fuels, e.g. patent fuel, brown-coal briquettes, coke-oven coke, gas coke, gas works gas, coke-oven gas, blast furnace gas and oxygen steel furnace gas. Peat is also included.

Concentrating solar power (CSP)**:** Thermal power generation technology that collects and concentrates sunlight to produce high temperature heat to generate electricity.

Conventional natural gas: Refers to natural gas extracted using traditional drilling techniques. It includes both onshore and offshore natural gas, including from the Arctic.

Conventional oil: Refers to oil extracted using traditional drilling methods. It includes onshore and offshore crude oil, including from the Arctic, enhanced oil recovery and natural gas liquids produced from conventional gas fields.

Critical minerals: A wide range of minerals and metals that are essential for key energy, digital and other modern technologies, but whose supply chains are vulnerable to disruption. While definitions and criteria vary across countries, they typically include chromium, cobalt, copper, gallium, germanium, graphite, lithium, manganese, molybdenum, nickel, platinum group metals, zinc and rare earth elements.

Data centres: Facilities that house information technology (IT) equipment, such as servers, storage systems and networking equipment, and are equipped with cooling and other auxiliary systems to keep the IT equipment operating under optimal conditions.

Decomposition analysis: A statistical method that decomposes an aggregate indicator to quantify the relative contribution of a set of pre-defined factors leading to a change in the aggregate indicator. The *World Energy Outlook* uses an additive index decomposition of the type Logarithmic Mean Divisia Index (LMDI).

Demand-side integration (DSI)**:** Consists of two types of measures: actions that influence load shape such as energy efficiency and electrification; and actions that manage load such as demand-side response measures.

Demand-side response (DSR)**:** Describes actions which can influence the load profile such as shifting the load curve in time without affecting total electricity demand, or load shedding such as interrupting demand for a short duration or adjusting the intensity of demand for a certain amount of time.

Direct air capture (DAC)**:** A type of carbon capture, utilisation and storage technology that captures CO_2 directly from the atmosphere using liquid solvents or solid sorbents. It is generally coupled with permanent storage of the CO_2 in deep geological formations or its use in the production of fuels, chemicals, building materials or other products. When coupled with permanent geological CO_2 storage, DAC is a carbon removal technology, and it is known as direct air capture and storage (DACS).

Dispatchable generation: Electricity from technologies whose power output can be readily controlled up to the nameplate capacity, i.e. increased to maximum rated capacity or decreased to zero, in order to help match supply with demand.

Electric arc furnace: Furnace that heats material by means of an electric arc. It is used for scrap-based steel production but also for ferroalloys, aluminium, phosphorus or calcium carbide.

Electric vehicles (EVs): Electric vehicles include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

Electricity demand: Defined as total gross electricity generation less own use generation, plus net trade (imports less exports), less transmission and distribution losses.

Electricity generation: Defined as the total amount of electricity generated by power only or combined heat and power plants including generation required for own use and before curtailment. This is also referred to as gross generation.

Electrolysis: Process of converting electric energy to chemical energy. Most relevant for the energy sector is water electrolysis, which splits water molecules into hydrogen and oxygen molecules. The resulting hydrogen is called electrolytic hydrogen.

End-use sectors: Include industry, transport, buildings and other, i.e. agriculture and other non-energy use.

Energy demand: See total energy supply.

Energy-intensive industries: Includes production and manufacturing in the branches of iron and steel, chemicals, non-metallic minerals (including cement), non-ferrous metals (including aluminium), and paper, pulp and printing.

Energy-related and industrial process CO_2 emissions: Carbon dioxide emissions from fuel combustion, industrial processes, and fugitive and flaring CO_2 from fossil fuel extraction. Unless otherwise stated, CO_2 emissions refer to energy-related and industrial process CO_2 emissions.

Energy sector greenhouse gas (GHG) emissions: Energy-related and industrial process CO_2 emissions plus fugitive and vented methane (CH_4) and nitrous oxide (N_2O) emissions from the energy and industry sectors.

Energy services: A personal or societal gain from the use of energy. Includes, *inter alia,* heating, cooling, lighting, entertainment, mobility, nourishment, hygiene and education. Also see useful energy.

Ethanol: An alcohol with broad application in the chemical sector and as a fuel additive. When produced from bioresources it is known as bioethanol, which has applications as biogasoline, a liquid fuel, and as a biochemical.

Fossil fuels: Coal, oil and natural gas. Total fossil fuel use is equal to unabated fossil fuels plus fossil fuels with carbon capture, utilisation and storage and non-energy use of fossil fuels.

Gaseous fuels: Fuels in gaseous form including natural gas, biogas, biomethane, hydrogen and synthetic methane.

Gases: See gaseous fuels.

Geothermal: Heat derived from the sub-surface of the earth, usually using a working fluid such as water and/or steam to bring the energy to the surface. Depending on its characteristics, geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity if the temperature is adequate.

Heat (end-use): Can be obtained from the combustion of fossil or renewable fuels, direct geothermal or solar heat systems, exothermic chemical processes and electricity (through resistance heating or heat pumps which can extract heat from ambient air and liquids). This category refers to the wide range of end-uses, including space and water heating, and cooking in buildings, desalination and process applications in industry. It does not include cooling applications.

Heat (supply): Obtained from the combustion of fuels, nuclear reactors, large-scale heat pumps, geothermal or solar resources. It may be used for heating or cooling, or converted into mechanical energy for transport or electricity generation. Commercial heat sold is reported under total final consumption with the fuel inputs allocated under power generation.

Heavy-duty trucks (HDTs): Include both medium freight trucks (gross weight 3.5 to 15 tonnes) and heavy freight trucks (gross weight >15 tonnes).

Heavy-duty vehicles (HDVs): Include both medium freight trucks (gross weight 3.5 to 15 tonnes), heavy freight trucks (gross weight >15 tonnes) and buses.

Heavy industries: Iron and steel, chemicals and cement.

Hydrogen: Hydrogen is used in the energy system as an energy carrier, as an industrial raw material, or is combined with other inputs to produce hydrogen-based fuels. Unless otherwise stated, hydrogen in this report refers to low-emissions hydrogen.

Hydrogen-based fuels: Includes ammonia and synthetic hydrocarbons (gases and liquids) that derive their energy content from a pure, or nearly pure, hydrogen feedstock. If produced from low-emissions hydrogen, these fuels are low-emissions hydrogen-based fuels.

Hydropower: Refers to the electricity produced in hydropower projects. It excludes output from pumped storage and marine (e.g. tidal and wave technologies).

Improved cook stoves: Intermediate and advanced improved biomass cook stoves (ISO tier > 1). It excludes basic improved stoves (ISO tier 0-1).

Industry: The sector includes fuel used within the manufacturing and construction industries. Key industry branches include iron and steel, chemicals and petrochemicals, cement, aluminium, and pulp and paper. Use by industries for the transformation of energy into another form or for the production of fuels is excluded and reported separately under other energy sector. There is an exception for fuel transformation in blast furnaces and coke ovens, which are reported within iron and steel. Consumption of fuels for the transport of goods is reported as part of the transport sector, while consumption of fuels by off-road vehicles is reported under the specific sector. For instance, fuels consumed by bulldozers as a part of industrial operations is reported in industry.

International aviation bunkers: Include the deliveries of aviation fuels to aircraft for international aviation. Fuel used by airlines for their road vehicles are excluded. The domestic/international split is determined on the basis of departure and landing locations and not by the nationality of the airline. For many countries this incorrectly excludes fuels used by domestically owned carriers for their international departures.

International marine bunkers: Include the quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is excluded and instead included in the residential, services and agriculture category.

Investment: Energy investment is the capital expenditure in fuel supply, the power sector, energy efficiency and other end-use. Fuel supply investment includes the production, transformation and transport of oil, gas, coal, low-emissions fuels and direct air capture. Power sector investment includes new construction and refurbishment of generation, electricity grids (transmission, distribution and public electric vehicle chargers), and battery storage. Energy efficiency investment includes efficiency improvements in buildings, industry and transport. Other end-use investment includes equipment for the direct use of renewables and other low-emissions fuels, electric vehicles, electrification in buildings, industry and international marine transport, and carbon capture, utilisation and storage in industry. Data and projections reflect capital expenditure over the lifetime of projects and are presented in real terms in year-2024 US dollars converted at market exchange rates unless otherwise stated. Total investment reported for a year reflects the amount spent in that year.

Levelised cost of electricity (LCOE)**:** An indicator of the expected average production cost for each unit of electricity generated by a technology over its economic lifetime. The LCOE combines into a single metric all the cost elements directly associated with a given power technology, including construction, financing, fuel, maintenance and costs associated with a carbon price. It does not include network integration or other indirect costs. For a more complete indicator, see value-adjusted levelised cost of electricity (VALCOE).

Light-duty vehicles (LDVs)**:** Include passenger cars and light commercial vehicles (gross vehicle weight < 3.5 tonnes).

Light industries: Include non-energy-intensive industries: food and tobacco; machinery; mining and quarrying; transportation equipment; textiles; wood harvesting and processing and construction.

Lignite: A type of coal that is used in the power sector mostly in regions near lignite mines due to its low energy content and typically high moisture levels, which generally make long-distance transport uneconomic.

Liquid biofuels: Liquid fuels derived from biomass or waste feedstock, including ethanol, biodiesel and biojet fuels. Unless otherwise stated, biofuels are expressed in energy-equivalent volumes of gasoline, diesel and kerosene.

Liquid fuels: Include oil, liquid biofuels, synthetic oil products and hydrogen-based fuels, i.e. ammonia and methanol.

Low-emissions electricity: Includes output from renewable energy technologies, nuclear power, fossil fuels fitted with carbon capture, utilisation and storage, hydrogen and ammonia.

Low-emissions fuels: Include modern bioenergy, low-emissions hydrogen and low-emissions hydrogen-based fuels.

Low-emissions gases: Include biogas, biomethane, low-emissions hydrogen and low-emissions synthetic methane.

Low-emissions hydrogen: Includes hydrogen that is produced through water electrolysis with electricity generated from a low-emissions source, e.g. solar, wind and nuclear power. Hydrogen produced from biomass or from fossil fuels with carbon capture, utilisation and storage (CCUS) technology is also counted as low-emissions hydrogen. Production from fossil fuels with CCUS is included only if upstream emissions are sufficiently low, if capture at high rates is applied to all CO_2 streams associated with the production route, and if all CO_2 is permanently stored to prevent its release into the atmosphere. The same principle applies to low-emissions feedstocks and hydrogen-based fuels made using low-emissions hydrogen and a sustainable carbon source of biogenic origin or directly captured from the atmosphere.

Low-emissions hydrogen-based fuels: Fuels produced from low-emissions hydrogen. Includes ammonia, methanol and other synthetic hydrocarbons (gases and liquids) made from low-emissions hydrogen when any carbon inputs, e.g. from CO_2, are not from fossil fuels or fossil-derived process emissions.

Low-emissions hydrogen-based liquid fuels: A subset of low-emissions hydrogen-based fuels that includes only ammonia, methanol and synthetic liquid hydrocarbons, such as synthetic kerosene.

Lower heating value: Heat liberated by the complete combustion of a unit of fuel when the water produced is assumed to remain as a vapour and the heat is not recovered.

Marine energy: Mechanical energy harvested from ocean currents, tidal movement or wave motion and exploited for electricity generation.

Mini-grids: Small electric grid systems, not connected to main electricity networks, linking a number of households and/or other consumers.

Modern energy access: Includes household access to a minimum level of electricity, initially equivalent to 250 kilowatt-hours (kWh) annual demand for a rural household and 500 kWh for an urban household; household access to less harmful and more sustainable cooking and heating fuels, and improved/advanced stoves; access that enables productive economic activity; and access for public services.

Modern gaseous bioenergy: See biogases.

Modern liquid bioenergy: Includes biogasoline, biodiesel, biojet kerosene and other liquid biofuels.

Modern renewables: Include all renewables with the exception of the traditional use of solid biomass.

Modern solid bioenergy: Includes all solid bioenergy products except the traditional use of biomass. It also includes the use of solid bioenergy in intermediate and advanced improved biomass cook stoves (ISO tier > 1), requiring fuel to be cut into small pieces or often using processed biomass such as pellets.

Natural gas: A gaseous fossil fuel, consisting mostly of methane. Occurs in deposits, whether liquefied or gaseous. In IEA analysis and statistics, it includes both non-associated gas originating from fields producing hydrocarbons only in gaseous form, and associated gas produced in association with crude oil production, as well as methane recovered from coal mines. Natural gas liquids, manufactured gas, i.e. produced from municipal or industrial waste or sewage, and quantities vented or flared are not included. Natural gas data in cubic metres are expressed on a gross calorific value basis and are measured at 15 °C and at 760 mm Hg (Standard Conditions). Natural gas data expressed in tonnes of oil equivalent, mainly to allow comparison with other fuels, are on a net calorific basis. The difference between the net and the gross calorific value is the latent heat of vaporisation of the water vapour produced during combustion of the fuel.

Natural gas liquids (NGLs)**:** Liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. NGLs are portions of natural gas recovered as liquids in separators, field facilities or gas processing plants. NGLs include, but are not limited to, ethane (when it is removed from the natural gas stream), propane, butane, pentane, natural gasoline and condensates.

Network gases: Gaseous fuels transported in a pipeline gas network, either separately or blended together. Include natural gas, biomethane, synthetic methane and hydrogen blended in a gas network.

Non-energy-intensive industries: See other industry.

Non-energy use: The use of energy products as raw materials for the manufacture of non-energy products, e.g. natural gas used to produce fertiliser, as well as for direct uses that do not involve using the products as a source of energy, or as a transformation input e.g. lubrication, sealing, roading surfacing, preservation or use as a solvent. Note that for biofuels, only the amounts specifically used for energy purposes, a small part of the total, are included in energy statistics. Therefore, the non-energy use of biomass is not taken into consideration, and the quantities are null by definition.

Non-renewable waste: Non-biogenic waste, such as plastics in municipal or industrial waste.

Nuclear power: Refers to the electricity produced by a nuclear reactor, assuming an average conversion efficiency of 33%.

Off-grid systems: Mini-grids and stand-alone systems for individual households or groups of consumers not connected to a main grid.

Offshore wind: Refers to electricity produced by wind turbines that are installed in open water, usually in the ocean. Includes fixed offshore wind (fixed to the seabed) and floating offshore wind.

Oil: A liquid fuel. Usually refers to fossil fuel mineral oil. Includes oil from both conventional and unconventional oil production. Petroleum products include refinery gas, ethane, liquid petroleum gas, aviation gasoline, motor gasoline, jet fuel, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirits, lubricants, bitumen, paraffin, waxes and petroleum coke.

Other energy sector: Covers the use of energy by transformation industries and energy losses in converting primary energy into a form that can be used in the final consuming sectors. It includes losses in low-emissions hydrogen and hydrogen-based fuels production, bioenergy processing, gas works, petroleum refineries, coal and gas transformation and liquefaction. It also includes energy own use in coal mines, in oil and gas extraction and in electricity and heat production. Transfers and statistical differences are also included in this category. Fuel transformation in blast furnaces and coke ovens are not accounted for in the other energy sector category.

Other industry: A category of industry branches that includes construction, food processing, machinery, mining, textiles, transport equipment, wood processing and remaining industry. It is sometimes referred to as non-energy-intensive industry.

Passenger car: A road motor vehicle, other than a moped or a motorcycle, intended to transport passengers. It includes vans designed and used primarily to transport passengers. Light commercial vehicles, motor coaches, urban buses and mini-buses/mini-coaches are excluded.

Peat: A solid formed from the partial decomposition of dead vegetation under conditions of high humidity and limited air access, i.e. initial stage of coalification. It is available in two forms for use as a fuel, sod peat and milled peat. Peat used for non-energy purposes is not included. Peat is included under data for lignite.

Power generation: Refers to electricity generation and heat production from all sources of electricity, including electricity-only power plants, heat plants and co-generation, i.e. combined heat and power plants. Both main activity producer plants and small plants that produce fuel for their own use, i.e. auto-producers, are included.

Process emissions: CO_2 emissions produced from industrial processes which chemically or physically transform materials. A notable example is cement production, in which CO_2 is emitted when calcium carbonate is transformed into lime, which in turn is used to produce clinker.

Process heat: The use of thermal energy to produce, treat or alter manufactured goods.

Productive uses: Energy used towards an economic purpose: agriculture, industry, services and non-energy use. Some energy demand from the transport sector, for example. freight, could be considered as productive, but is treated separately.

Primary chemicals: Include ethylene, propylene, benzene, toluene, mixed xylenes, ammonia and methanol.

Rare earth elements (REEs)**:** A group of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides plus scandium and yttrium. REEs are vital inputs for key energy technologies, including wind turbines, electric vehicle motors and electrolysers.

Renewables: Include bioenergy, geothermal, hydropower, solar photovoltaics, concentrating solar power, wind and marine (tidal and wave) energy for electricity and heat generation.

Residential: Energy used by households including space heating and cooling, water heating, lighting, appliances, electronic devices and cooking.

Road transport: This refers to all road vehicle types, i.e. passenger cars, two/three-wheelers, light commercial vehicles, buses and medium and heavy freight trucks.

Self-sufficiency: Corresponds to indigenous production divided by total energy supply.

Services: A component of the buildings sector. It represents energy used in commercial facilities, e.g. offices, shops, hotels, restaurants, and in institutional buildings such as schools, hospitals and public offices. Energy use in services includes space heating and cooling, water heating, lighting, appliances, cooking, data centres and desalination.

Shale gas: A type of unconventional natural gas contained within a commonly occurring rock classified as shale. Shale formations are characterised by low permeability, with more limited ability for gas to flow through the rock than is the case within a conventional reservoir. Shale gas is generally produced using hydraulic fracturing. See also tight oil.

Shipping/navigation: This transport mode includes both domestic and international navigation and their use of marine fuels. Domestic navigation covers the transport of goods or people on inland waterways and for national sea voyages (starts and ends in the same country without any intermediate foreign port). International navigation includes quantities of fuels delivered to merchant ships, including passenger ships, of any nationality for consumption during international voyages transporting goods or passengers.

Solar: Includes solar photovoltaics (PV), concentrating solar power (CSP), and solar heating and cooling.

Solar home systems (SHS)**:** Small-scale photovoltaic and battery stand-alone systems, i.e. with capacity higher or equal to 10 watt peak (Wp) supplying electricity for single households or small businesses. They are most often used off-grid, but also where grid supply is not reliable. Although all SHS are included in the IEA access to electricity definition and historic counting, only solar home systems from 25 Wp in rural areas and 50 Wp in urban areas are deployed in the IEA scenarios for population gaining access. It excludes solar systems smaller than 10 Wp, i.e. multi light systems and solar lanterns.

Solar photovoltaics (PV)**:** Electricity produced from solar photovoltaic cells including utility-scale and small-scale installations.

Solid bioenergy: Includes charcoal, fuelwood, dung, agricultural residues, wood waste and other solid biogenic wastes.

Solid fuels: Include coal, modern solid bioenergy, traditional use of biomass and industrial and municipal wastes.

Stand-alone systems: Small-scale autonomous electricity supply for households or small businesses. They are generally used off-grid, but also where grid supply is not reliable. Stand-alone systems include solar home systems, small wind or hydro generators, diesel or gasoline generators. The difference compared with mini-grids is in scale and that stand-alone systems do not have a distribution network serving multiple costumers.

Steam coal: A type of coal that is mainly used for heat production or steam-raising in power plants and, to a lesser extent, in industry. Typically, steam coal is not of sufficient quality for steel making. Coal of this quality is also commonly known as thermal coal.

Synthetic methane: Methane from sources other than natural gas, including coal-to-gas and low-emissions synthetic methane.

Synthetic oil: Liquid fuels obtained via a process other than the refining of crude oil or bituminous oils. Synthetic oil is produced through Fischer-Tropsch conversion or methanol synthesis. It includes oil products from coal-to-liquids, gas-to-liquids and non-ammonia low-emissions liquid hydrogen-based fuels.

Tight oil: A type of unconventional oil produced from shale or other very low permeability formations, generally using hydraulic fracturing. Sometimes referred to as light tight oil. Tight oil includes tight crude oil and condensate production except for the United States, which includes tight crude oil only. (US tight condensate volumes are included in natural gas liquids).

Total energy supply (TES)**:** Represents domestic demand only, and is equivalent to electricity and heat generation plus the other energy sector, excluding electricity, heat and hydrogen, plus total final consumption, excluding electricity, heat and hydrogen. TES does not include ambient heat from heat pumps or electricity trade.

Total final consumption (TFC)**:** Is the sum of consumption by the various end-use sectors. TFC is broken down into energy demand in the following sectors: industry (including manufacturing, mining, chemicals production, blast furnaces and coke ovens); transport; buildings (including residential and services); and other (including agriculture and other non-energy use). It excludes international marine and aviation bunkers, except at world level where it is included in the transport sector.

Total final energy consumption (TFEC)**:** Is a variable defined primarily for tracking progress towards target 7.2 of the United Nations Sustainable Development Goals (SDG). It incorporates total final consumption by end-use sectors, but excludes non-energy use. It excludes international marine and aviation bunkers, except at world level. Typically, this is used in the context of calculating the renewable energy share in total final energy consumption (indicator SDG 7.2.1), where TFEC is the denominator.

Traditional use of biomass: Refers to the use of solid biomass with basic technologies, such as a three-stone fire or basic improved cook stoves (ISO tier 0-2), often with no or poorly operating chimneys. Forms of biomass used include wood, wood waste, charcoal, agricultural residues and other bio-sourced fuels such as animal dung.

Transport: Includes fuels and electricity used in the transport of goods or people within the national territory irrespective of the economic sector within which the activity occurs. This includes: fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Energy consumption from marine and aviation bunkers is presented only at the world level and is excluded from the transport sector at a domestic level.

Trucks: Includes all size categories of commercial vehicles: light trucks (gross vehicle weight < 3.5 tonnes); medium freight trucks (gross vehicle weight 3.5-15 tonnes); and heavy freight trucks (gross vehicle weight > 15 tonnes).

Unabated fossil fuel use: Fossil fuels used for energy purposes without carbon capture, utilisation and storage (CCUS). Total fossil fuel use is equal to unabated fossil fuels plus fossil fuels with CCUS plus non-energy use of fossil fuels.

Unconventional natural gas: Includes tight gas, shale gas, coalbed methane, gas hydrates and coal-to-gas products.

Unconventional oil: Includes mining and in-situ extra-heavy oil and bitumen, synthetic crudes made by upgrading bituminous, e.g., oil sands in Canada, or extra-heavy crude oils, light tight oil, kerogen oil, coal-to-liquids (CTL) and gas-to-liquids (GTL) products, additives and natural gas liquids from unconventional natural gas fields.

Useful energy: Energy available to end-users to satisfy their need for energy services. As a result of transformation losses at the point of use, the amount of useful energy is lower than the corresponding final energy demand for most technologies. See energy services.

Value-adjusted levelised cost of electricity (VALCOE): A more complete metric to evaluate the competitiveness of power generation technologies, which includes all direct technology costs (LCOE) combined with the estimated value of three services provided to the system: energy, flexibility and capacity.

Variable renewable energy (VRE): Sources of renewable energy, usually electricity, where the maximum output of an installation at a given time depends on the availability of fluctuating environmental inputs. VRE includes a broad array of technologies such as wind power, solar PV, run-of-river hydro, concentrating solar power where no thermal storage is included, and marine (tidal and wave).

Zero carbon-ready buildings: A zero carbon-ready building is highly energy efficient and either uses renewable energy directly or an energy supply that can be fully decarbonised, such as electricity or district heat.

Zero emissions vehicles (ZEVs): Vehicles that operate without tailpipe CO_2 emissions, i.e. battery electric, plug-in hybrids and fuel cell vehicles.

Regional and country groupings

Advanced economies: Organisation for Economic Co-operation and Development (OECD) grouping and Bulgaria, Croatia, Cyprus[1,2], Malta and Romania.

Africa: North Africa and sub-Saharan Africa regional groupings.

Asia Pacific: Southeast Asia regional grouping and Australia, Bangladesh, Democratic People's Republic of Korea (North Korea), India, Japan, Korea, Mongolia, Nepal, New Zealand, Pakistan, The People's Republic of China (China), Sri Lanka, Chinese Taipei, and other Asia Pacific countries and territories.[3]

Caspian: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

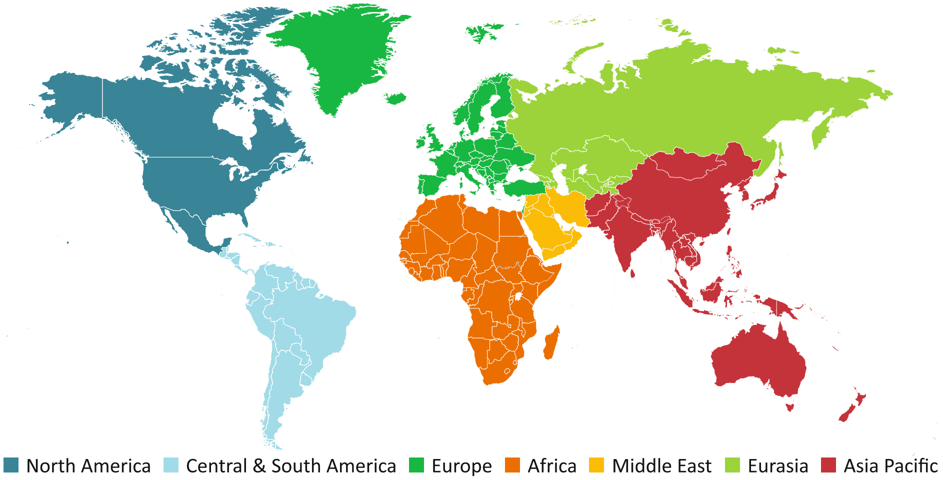
Central and South America: Argentina, Plurinational State of Bolivia (Bolivia), Bolivarian Republic of Venezuela (Venezuela), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and other Central and South American countries and territories.[4]

China: Includes (The People's Republic of) China and Hong Kong, China.

Developing Asia: Asia Pacific regional grouping excluding Australia, Japan, Korea and New Zealand.

Emerging market and developing economies: All other countries not included in the advanced economies regional grouping.

Figure C.1 ▷ Main country groupings



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Eurasia: Caspian regional grouping and the Russian Federation (Russia).

Europe: European Union regional grouping and Albania, Belarus, Bosnia and Herzegovina, Gibraltar, Iceland, Israel[5], Kosovo[6], Montenegro, North Macedonia, Norway, Republic of Moldova, Serbia, Switzerland, Türkiye, Ukraine and United Kingdom.

European Union: Austria, Belgium, Bulgaria, Croatia, Cyprus[1,2], Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden.

IEA (International Energy Agency)**:** Australia, Austria, Belgium, Canada, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, The Netherlands, Türkiye, United Kingdom and United States.

Latin America and the Caribbean (LAC)**:** Central and South America regional grouping and Mexico.

Middle East: Bahrain, Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic (Syria), United Arab Emirates and Yemen.

Non-OECD: All other countries not included in the OECD regional grouping.

Non-OPEC: All other countries not included in the OPEC regional grouping.

North Africa: Algeria, Egypt, Libya, Morocco and Tunisia.

North America: Canada, Mexico and United States.

OECD (Organisation for Economic Co-operation and Development)**:** IEA grouping plus Chile, Colombia, Costa Rica, Iceland, Israel, Latvia and Slovenia.

OPEC (Organization of the Petroleum Exporting Countries)**:** Algeria, Angola, Bolivarian Republic of Venezuela (Venezuela), Equatorial Guinea, Gabon, Iraq, Islamic Republic of Iran (Iran), Kuwait, Libya, Nigeria, Republic of the Congo (Congo), Saudi Arabia and United Arab Emirates.

OPEC+: OPEC grouping plus Azerbaijan, Bahrain, Brunei Darussalam, Kazakhstan, Malaysia, Mexico, Oman, Russian Federation, South Sudan and Sudan.

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. These countries are all members of the Association of Southeast Asian Nations (ASEAN).

Sub-Saharan Africa: Angola, Benin, Botswana, Cameroon, Côte d'Ivoire, Democratic Republic of the Congo (DRC), Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Kingdom of Eswatini, Madagascar, Mauritius, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo (Congo), Rwanda, Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania (Tanzania), Togo, Uganda, Zambia, Zimbabwe and other African countries and territories.[7]

Country notes

[1] Note by Republic of Türkiye: The information in this document with reference to “Cyprus” relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the “Cyprus issue”.

[2] Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

[3] Individual data are not available and are estimated in aggregate for: Afghanistan, Bhutan, Cook Islands, Fiji, French Polynesia, Kiribati, Macau (China), Maldives, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga and Vanuatu.

[4] Individual data are not available and are estimated in aggregate for: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands (Malvinas), Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and Grenadines, Saint Maarten (Dutch part), Turks and Caicos Islands.

[5] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD and/or the IEA is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

[6] This designation is without prejudice to positions on status, and is in line with United Nations Security Council Resolution 1244/99 and the Advisory Opinion of the International Court of Justice on Kosovo’s declaration of independence.

[7] Individual data are not available and are estimated in aggregate for: Burkina Faso, Burundi, Cabo Verde, Central African Republic, Chad, Comoros, Djibouti, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Malawi, Mali, Mauritania, Sao Tome and Principe, Seychelles, Sierra Leone and Somalia.

Abbreviations and acronyms

AC	alternating current
AFOLU	agriculture, forestry and other land use
APS	Announced Pledges Scenario
BAT	best available technology
BEV	battery electric vehicles
CAAGR	compound average annual growth rate
CAPEX	capital expenditures
CBC	Capricorn Bioceanic Corridor
CCGT	combined-cycle gas turbine
CCUS	carbon capture, utilisation and storage
CDD	cooling degree day
CDR	carbon dioxide removal
CEN	Coordinador Eléctrico Nacional
CH_4	methane
CHP	combined heat and power; the term co-generation is sometimes used
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide

CO_2-eq	carbon-dioxide equivalent
CORFO	Corporación de Fomento de la Producción
CSP	concentrating solar power
DAC	direct air capture
DACS	direct air capture and storage
DC	direct current
DER	distributed energy resources
DEVEX	development expenditure
DLE	direct lithium extraction
DRI	direct reduced iron
DSI	demand-side integration
DSO	distribution system operator
DSR	demand-side response
EDGE	excellence in design for greater efficiencies
ENAP	Empresa Nacional del Petróleo
EOR	enhanced oil recovery
ETS	emissions trading system
EU	European Union
EV	electric vehicle
FACTS	flexible AC transmission systems
FAO	Food and Agriculture Organization of the United Nations
FCEV	Fuel cell electric vehicle
FDI	foreign direct investment
FDN	Financiera de Desarrollo Nacional
FEPC	Fondo de Estabilización de Precios de los Combustibles
FID	final investment decision
GEC	Global Energy and Climate (IEA model)
GDP	gross domestic product
GHG	greenhouse gases
GTL	gas-to-liquids
H_2	hydrogen
HDD	heating degree day
HDV	heavy-duty vehicle
HFO	heavy fuel oil
HVDC	high-voltage direct current
ICE	internal combustion engine
ICZ	Intertropical Convergence Zone
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
IOC	international oil company
IPCC	Intergovernmental Panel on Climate Change

IPF	international public finance
IPT	independent power transmission
IT	Information technology
JETS	Just Energy Transition Strategy
LAC	Latin America and the Caribbean
LCE	lithium carbonate equivalent
LCOE	levelised cost of electricity
LCV	light commercial vehicle
LDV	light-duty vehicle
LED	light-emitting diode
LFP	lithium iron phosphate
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MEPS	minimum energy performance standards
MER	market exchange rate
NDC	Nationally Determined Contribution
NOC	national oil company
NPV	net present value
NO_X	nitrogen oxides
N_2O	nitrous oxide
NZE	Net Zero Emissions by 2050 Scenario
OPEC	Organization of the Petroleum Exporting Countries
OPEX	operating expenditures
PELP	Planificación Energética de Largo Plazo
PHEV	plug-in hybrid electric vehicles
PLDV	passenger light-duty vehicle
PM	particulate matter
$PM_{2.5}$	fine particulate matter
PNACC	Plan nacional de adaptación al cambio climático
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaics
R&D	research and development
SAF	sustainable aviation fuel
SDG	Sustainable Development Goals (United Nations)
SEA	Sistema Eléctrico de Aysén
SEAD	Super-Efficient Equipment and Deployment
SEM	Sistema Eléctrico de Magallanes
SEN	Sistema Eléctrico Nacional
SHS	solar home systems
SITP	Sistema Integrado de Transporte Público
SME	small and medium enterprise
SMR	steam methane reforming

SO_2	sulphur dioxide
SOEs	state-owned enterprises
SPI	Standardised Precipitation Index
STEPS	Stated Policies Scenario
T&D	transmission and distribution
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
TPED	total primary energy demand
TSO	transmission system operator
UN	United Nations
US	United States
USGS	United States Geological Survey
VA	value-added
VALCOE	value-adjusted levelised cost of electricity
VRE	variable renewable energy
WACC	weighted average cost of capital
WAMS	wide-area monitoring system
WEO	World Energy Outlook
WHO	World Health Organization
WTO	World Trade Organization
ZEV	zero emissions vehicle
ZCRB	zero carbon-ready building

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Chile 2050 Energy Transition Roadmap

World Energy Outlook Special Report

Chile has made significant strides in its energy transition, towards its ambitious long-term goals and it stands at a pivotal moment in its energy journey, possessing remarkable renewable and critical mineral resources.

The *Chile 2050 Energy Transition Roadmap*, produced at the request of the Government of Chile, and in close collaboration with the Chilean Ministry of Energy, sets out a detailed pathway for the country to reach its legally binding goal of net zero emissions by 2050 while expanding economic growth and improving energy security and affordability. This pathway relies on four pillars: accelerating energy efficiency, decarbonising the power sector, electrifying end-use sectors, and building modern, resilient electricity grids. The report examines the investment needed to realise the pathway, the opportunities to reduce household bills, and the improvement of air quality. It explores how Chile can also leverage its natural resources in the global energy transition with opportunities for the country to move up the value chain in critical mineral production and become a competitive global exporter of low-emissions hydrogen.