IRENA
International Renewable Energy Agency

# Regional energy transition outlook

# SOUTH AMERICA

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## About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

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International Renewable Energy Agency

# REGIONAL ENERGY TRANSITION OUTLOOK

# SOUTH AMERICA

# FOREWORD

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The world is achieving steady progress in the energy transition. A record 582 GW of new renewable energy capacity was added in 2024, and renewable energy investments surpassed that of fossil fuels globally for the first time. The installed costs of renewable technologies continue to fall despite challenging headwinds, driving further investment and deployment. South America has contributed strongly to this global trend in renewables expansion, with 23 GW of renewable capacity added in 2024, confirming its position as one of the world's most competitive regions for clean energy.

Despite this momentum, IRENA data shows that a significant gap remains to reach the 1.5°C target of the Paris Agreement. Yet, South America – already rich in renewable resources, and with a share of renewables in power generation in excess of 80% – can accelerate progress to achieve a fully decarbonised and inclusive energy system.

Understanding that the global energy transition is progressing at different rates across regions, IRENA produces regional energy transition outlooks to support local action. This edition in the series focusses on South America, and represents a timely contribution to the Action Agenda of the COP30 Brazilian Presidency.

The study assesses both energy demand and supply across the transport, industry, buildings, fuels and power sectors, evaluating existing policies and exploring more ambitious pathways to decarbonisation. Through detailed country-level analysis, it identifies options to reduce emissions while promoting fairness and social benefits, and outlines the investment and expenditure needs, policy priorities, and infrastructure requirements necessary to achieve these goals. The analysis also highlights key barriers and gaps, as well as sector-specific investment and financing needs. Built on existing national energy plans as a foundation, the study develops additional transition scenarios and provides targeted policy recommendations informed by these findings.

Strong engagement with South American countries and close cooperation with regional partners, such as IDB, OLADE and ECLAC, were essential for this study. It offers guidance for policy makers in the region to shape their national energy planning and Nationally Determined Contributions, as well as inputs for local infrastructure and investment planning. For private stakeholders, it offers information for strategic planning and risk assessment.

The report emphasises the positive role of regional collaboration to accelerate the energy transition and deliver socio-economic gains. It also highlights the importance of sustainable fuels production, and the wider potential expansion of renewable energy to drive industrial decarbonisation and create new value chains.

Renewables could supply nearly all power generation in the region by 2050; but this will require expanded interconnections to enhance flexibility and reliability, alongside strong investment in domestic grids to support the rapid electrification of buildings, transport and industry.

# CONTENTS

# FIGURES

# TABLES



# BOXES

# ABBREVIATIONS

| | |
|---|---|
| **ABAL** | Brazilian Aluminium Association |
| **AI** | artificial intelligence |
| **ALACERO** | Latin American Steel Association |
| **ANEEL** | National Electrical Energy Agency |
| **BAT** | best available technology |
| **BECCS** | Bioenergy with carbon capture and storage |
| **BESS** | battery energy storage system |
| **BEV** | Battery electric vehicle |
| **BIP** | Brazilian Climate and Ecological Transformation Investment Platform |
| **BNDES** | National Bank for Economic and Social Development |
| **°C** | degree Celsius |
| **CAGR** | compound annual growth rate |
| **CCS** | carbon capture and storage |
| **CCUS** | carbon capture, utilisation and storage |
| **$CO_2$** | carbon dioxide |
| **COP** | Conference of the Parties |
| **COP** | Columbian pesos (currency) |
| **CORSIA** | Carbon Offsetting and Reduction Scheme for International Aviation |
| **CSP** | concentrating solar power |
| **DER** | distributed energy resources |
| **DES** | Decarbonising Energy Scenario |
| **DFI** | development finance institution |
| **DG** | distributed generation |
| **EAF** | electric arc furnace |
| **ECLAC** | Economic Commission for Latin America and the Caribbean |
| **EJ** | exajoule |
| **EPE** | Energy Research Office |
| **ETS** | emissions trading scheme |
| **EU** | European Union |
| **EV** | electric vehicle |
| **FAME** | fatty acid methyl esters |
| **FEC** | final energy consumption |
| **G20** | Group of 20 |
| **GCEP** | Global Coalition for Energy Planning |
| **GDP** | gross domestic product |
| **GHG** | greenhouse gas |
| **GIZ** | Deutsche Gesellschaft für Internationale Zusammenarbei |
| **GJ** | gigajoule |
| **GOWA** | Global Offshore Wind Alliance |
| **Gt** | gigaton |
| **GW** | gigawatt |
| **GWh** | gigawatt hour |
| **H24U** | Hydrogen for You |
| **H2LAC** | Platform for the Development of Green Hydrogen in Latin America and the Caribbean |
| **HVO** | hydro treated vegetable oil |
| **IAI** | International Aluminium Institute |
| **IATA** | International Air Transport Association |
| **ICAO** | The International Civil Aviation Organization |
| **ICE** | internal combustion engine |
| **IDB** | Inter-American Development Bank |
| **IICA** | Inter-American Institute for Cooperation on Agriculture |
| **IMO** | International Maritime Organization |
| **IRENA** | International Renewable Energy Agency |
| **kg** | kilogramme |
| **KPI** | key performance indicator |
| **kW** | kilowatt |
| **kWh** | kilowatt hour |
| **LAC** | Latin America and the Caribbean |
| **LCOE** | levelised cost of electricity |
| **LED** | light emitting diode |
| **lge** | litres of gasoline equivalent |
| **LPG** | liquefied petroleum gas |
| **LPI** | Logistics Performance Index (World Bank) |
| **$m^3$** | cubic metre |
| **MBOE** | million barrels of oil equivalent |
| **MEPS** | minimum performance standards |
| **MERCOSUR** | Southern Common Market |
| **MJ** | megajoule |
| **Mt** | million tonne |
| **$MtCO_2$** | million tonnes of carbon dioxide |
| **Mtep** | million tonnes of equivalent of petroleum |

| | |
|---|---|
| **MW** | megawatt |
| **MWh** | megawatt hour |
| **NDC** | Nationally Determined Contribution |
| **OLADE** | Latin America Energy Organization |
| **PAI PROURE** | Action Plan for PROURE |
| **PES** | Planned Energy Scenario |
| **PJ** | petajoule |
| **PROURE** | Programme for the Rational and Efficient Use of Energy |
| **PV** | photovoltaic |
| **R&D** | research and development |
| **REHIDRO** | Special Incentives Scheme for the Production of Low-Carbon Hydrogen |
| **RELAC** | Renewables in Latin America and the Caribbean |
| **REmap** | Renewable Energy Roadmap |
| **RETO** | regional energy transition outlook |
| **SAF** | sustainable aviation fuel |
| **SDG** | Sustainable Development Goal |
| **SIESUR** | Energy Integration System of the Southern Cone Countries |
| **SINEA** | Andean Electrical Integration System |
| **t** | tonne |
| **TES** | Transforming Energy Scenario |
| **TFEC** | total final energy consumption |
| **TPES** | total primary energy supply |
| **TW** | terawatt |
| **TWh** | terawatt hour |
| **USD** | United States dollar |
| **VAT** | value added tax |
| **VRE** | variable renewable energy |
| **WACC** | weighted average cost of capital |
| **WETO** | World energy transitions outlook |

| COUNTRY CODE | SHORT NAME | OFFICIAL NAME |
|---|---|---|
| AR | Argentina | The Argentine Republic |
| BO | Bolivia | The Plurinational State of Bolivia |
| BR | Brazil | The Federative Republic of Brazil |
| CL | Chile | The Republic of Chile |
| CO | Colombia | The Republic of Colombia |
| EC | Ecuador | The Republic of Ecuador |
| GF | French Guiana | French Guiana |
| GY | Guyana | The Co-operative Republic of Guyana |
| PY | Paraguay | The Republic of Paraguay |
| PE | Peru | The Republic of Peru |
| SR | Suriname | The Republic of Suriname |
| UY | Uruguay | The Eastern Republic of Uruguay |
| VE | Venezuela | The Bolivarian Republic of Venezuela |

# EXECUTIVE SUMMARY

In South America, there are five main drivers behind the energy transition: economic opportunity, innovation and competitiveness, geopolitical dynamics, climate change mitigation, and the pursuit of social and energy security.

**The energy transition in South America is robust and consistent, presenting a great opportunity for businesses and societies, particularly for emerging markets and developing economies**.

In United States dollar (USD) terms, the world needs USD 150 trillion of investment in the energy transition over the next 25 years, if it is to meet the Paris Agreement's 1.5°C target. South America alone needs around USD 500 billion of investment in projects and expenditure in goods for end-use applications each year over that period, if it is to achieve that goal. Yet, despite this high cost, roadmaps aiming to keep the temperature well below 2°C by end of the century – such as the International Renewable Energy Agency's (IRENA) Decarbonising Energy Scenario (DES) – show that the net economic and social benefits for the region of achieving that goal more than outweigh the upfront costs.

Under the DES, by 2050, the energy transition is expected to create more than 12 million jobs in the South American energy sector. In addition, the region is expected to improve its gross domestic product (GDP) by an additional 1.1% on average each year over the 2023-2050 period, compared to the Planned Energy Scenario (PES) – the International Renewable Energy Agency's primary reference scenario. There would also be positive improvements in terms of human welfare. Under the DES, with investment being the main driver of GDP difference between the DES and PES. The role of household consumption is also significant, however, with this growing further after 2030.

The energy transition also offers opportunities to strengthen and diversify local supply chains across South America. This would enable countries to capture more value-added from domestic manufacturing and from the local provision of services. These services would be in areas such as renewable technologies, grids, storage solutions and efficiency improvements. This would be an important benefit both for national industrial competitiveness and resilience.

While employment in oil and gas production declines, new jobs in transition-related sectors, such as renewable energy, energy efficiency, grids and grid-flexibility, will outweigh those losses. The transition also reduces reliance on fossil fuels and improves energy security, along with South America's trade and fiscal balances.

**In recent decades, cost reductions in renewable energy technology and increased innovation have benefitted the energy transition and economic competitiveness.**

These benefits can be seen in many areas, including: 1) energy efficiency solutions; 2) technologies that can replace fossil fuels; 3) the development of the supply chain needed to handle the massive scaling-up of electricity production from renewable energy and fuels; and 4) the ongoing improvement of infrastructure, such as electricity grids.

Between 2010 and 2024, the levelised cost of electricity (LCOE) produced by solar photovoltaic (PV) panels declined from USD 0.417 per kilowatt hour (kWh)[1] to USD 0.043/kWh, while the LCOE of onshore wind fell from USD 0.113/kWh to USD 0.034/kWh (IRENA, 2025a). Today, in most regions, power generation using renewables is cheaper than using fossil fuels. South America is now one of the most competitive regions in the world for renewable power generation, with 2024 seeing it record average LCOEs of USD 0.054/kWh for solar PV and USD 0.036/kWh for onshore wind (IRENA, 2025a).

**The energy transition favours countries with abundant local renewable energy supplies, as well the those with abundant critical minerals for the energy transition. Current geopolitical dynamics are reshaping policy makers' priorities, with the strategic importance of energy coming to the forefront.**

The global geopolitical context has become increasingly unstable, marked by growing conflicts over trade and governance. These are leading to disruptions in global supply chains, financial sanctions, non-financial barriers and even military confrontations. This more fragmented global economy is causing a reprioritisation of resource allocation towards security, in all its forms, including energy security and resilience.

In this context, with its abundant, diverse and cost-competitive renewable resource potential and abundant critical mineral resources, South America is well placed as a safe harbour for green investments, while also being a reliable source of sustainable energy. Abundant renewable resources also allow diversification of renewable deployment and less dependence on a few sources. This is true for the South American electricity sector and hydropower, for example. Given the availability of biofuels, electrification is also only one solution among several available around the region.

**The need for an energy transition is more urgent than ever. Global carbon dioxide ($CO_2$) emissions remain dangerously high, registering around 38 gigatonnes (Gt) in 2023 (Global Carbon Budget, 2025). This leaves the world far from achieving its net-zero targets, while climate change advances.**

According to the National Bureau of Economic Research in the United States, a 1°C increase in global temperature could result in a decline in global GDP of over 10% (World Economic Forum, 2024). Indeed, societies and individuals around the world are already suffering the consequences of climate change. South America – which was responsible for around 3% of global energy-related emissions in 2023 – is currently witnessing increasingly extreme climate events, impacting livelihoods. Postponing action on climate change implies increasing the costs of mitigation and adaptation for all. The energy transition in South America can also be a strategy to cope with and adapt to climate change.

[1] *All USD amounts specified in this report are in 2024 United States dollars unless otherwise stated.*

**Current trends show economic policies being adjusted to promote national security and respond to both global economic uncertainties and climate change concerns.**

These policies, aimed at securing national institutions and economies, prioritise or strengthen local value chains and domestic production related to the energy transition. They do this by using local energy resources, enhancing energy security, embedding resilience and climate adaptation, and boosting research and development (R&D). They also do this by setting up mechanisms to guarantee access to raw materials and other critical goods essential to the energy transition – particularly when local supply is limited. The European Union (EU), India, China and the United States (US) are key examples where such policies are being implemented, but all countries and regions are being affected, directly or indirectly, by these external policy changes. South America is no exception; implementing regional energy transition roadmaps can support the region by strategically strengthening its economic resilience and competitive advantages. In this context, managing and planning for the decline of global oil and gas consumption and production is also crucial for the region's fossil fuel producing countries.

## Pathways to decarbonisation

In order to explore what the energy transition might entail for South America, this report sets out a roadmap to a decarbonised energy future.

The report presents a dashboard of key performance indicators (KPIs) for the energy transition. This uses the milestones suggested by IRENA for 2030, 2040 and 2050 that South American countries should aim for and use to inform regional objectives (Table S1). These milestones are aligned with the global goals endorsed under the UAE Consensus at COP28 to triple renewable energy and double the rate of energy improvement by 2030, as well as with the objectives of the Paris Agreement to limit global warming to 1.5°C above pre-industrial levels, and the Sustainable Development Goals (SDGs). They are followed by a suggested roadmap consisting of a list of selected actions, policies and mechanisms to be implemented by 2030, 2040 and 2050.

There are KPIs for renewable power, the direct use of renewables (including biofuels), energy efficiency, electrification, clean hydrogen, carbon capture and storage (CCS) and bioenergy with carbon capture and storage (BECCS), among others. Socio-economic KPIs include cumulative and annual deployment of investments and the costs of their main components for the overall energy sector.

**Table S1** KPIs in South America for the PES and DES, 2023-2050

| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **KPI.01 RENEWABLES (POWER)** | | | | | | | |
| Renewable energy electricity generation (TWh/yr) | 982 | 1 318 | 1 854 | 2 464 | 1 524 | 3 057 | 4 967 |
| Renewable energy share in electricity generation (%) | 79% | 89% | 92% | 93% | 91% | 97% | 98% |
| Renewable energy installed capacity (GW) | 290 | 382 | 563 | 822 | 428 | 907 | 1 687 |
| Solar PV capacity (GW)[1] | 50 | 112 | 230 | 410 | 133 | 397 | 927 |
| Wind capacity (GW)[2] | 40 | 59 | 111 | 186 | 77 | 247 | 427 |
| Hydro capacity (GW)[3] | 180 | 189 | 200 | 203 | 191 | 210 | 246 |
| Renewable energy share in installed capacity (%) | 71% | 76% | 76% | 78% | 77% | 80% | 86% |
| **KPI.02 RENEWABLES** | | | | | | | |
| Total primary energy supply (EJ) | 24 | 28 | 33 | 39 | 28 | 32 | 37 |
| Renewable energy share in TPES (%) | 36% | 43% | 46% | 48% | 52% | 66% | 85% |
| Total final energy consumption (EJ)[4] | 19 | 22 | 27 | 32 | 21 | 23 | 24 |
| Renewable energy share in TFEC (%) - direct + indirect | 32% | 38% | 42% | 45% | 40% | 59% | 81% |
| Renewable energy share TFEC (%) - direct only | 20% | 22% | 22% | 22% | 23% | 28% | 34% |
| Modern use of bioenergy (EJ) | 3.7 | 4.5 | 6.0 | 7.3 | 4.9 | 7.2 | 9.2 |
| Biofuels production volume (billion L)[5] | 40 | 61 | 88 | 111 | 63 | 87 | 97 |
| **KPI.03 ENERGY INTENSITY** | | | | | | | |
| Energy intensity improvement rate (%)[6] | 0.8% | 0.7% | 0.2% | 0.5% | 0.7% | 0.6% | 1.0% |
| **KPI.04 ELECTRIFICATION IN END-USE SECTORS (DIRECT)** | | | | | | | |
| Electrification rate in TFEC (%) | 20% | 21% | 23% | 25% | 22% | 33% | 48% |
| Electricity consumption (TWh) | 1 049 | 1 252 | 1 704 | 2 229 | 1 274 | 2 077 | 3 105 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **KPI.05** CLEAN HYDROGEN AND DERIVATIVES | | | | | | | |
| Production of clean hydrogen ($MtH_2eq$)[7] | 0[8] | 0.002 | 0.2 | 0.9 | 2.8 | 11 | 22 |
| **KPI.06** CCS, BECCS AND OTHERS | | | | | | | |
| Energy and process $CO_2$ captured from CCS, BECCS and other removal measures ($MtCO_2$) | 0 | 0 | 1.3 | 5.0 | 0 | 65 | 127 |
| SOCIO-ECONOMICS | | | | | | | |
| Energy sector jobs (in million) | 5.8 | 6.1 | 7.2 | 7.7 | 6.8 | 9.8 | 12.4 |
| Renewable energy jobs (in million) | 1.7 | 1.9 | 2.0 | 2.1 | 2.0 | 2.6 | 3.1 |
| Other transition-related jobs (in million) | 0.9 | 1.5 | 2.4 | 2.9 | 2.5 | 5.9 | 8.4 |
| Fossil fuels jobs (in million) | 3.1 | 2.7 | 2.9 | 2.7 | 2.4 | 1.3 | 0.9 |
| Share of clean cooking technologies in residential stock (%)[9] | 7% | 5.6% | 9% | 12% | 6.3% | 47% | 87% |
| TOTAL SYSTEM COSTS[10] | | | | | | | |
| Cumulative - investment (2024 USD trillion) | - | 0.5 | 1.2 | 1.7 | 0.8 | 2.5 | 4.2 |
| Cumulative - expenditure (2024 USD trillion) | - | 0.7 | 1.5 | 1.9 | 0.7 | 1.9 | 2.8 |
| Cumulative - fuel costs (2024 USD trillion) | - | 2.8 | 5.7 | 6.9 | 2.8 | 4.5 | 3.4 |

**Notes:**

1 *Solar PV capacity includes utility-scale and distributed resources.*

2 *Wind capacity considers onshore and offshore installations.*

3 *Hydro capacity considers large and small/mini installations.*

4 *TFEC value includes "non-energy" uses.*

5 *Biofuels refer to biodiesel and bioethanol. Values include exports.*

6 *Comparison of energy intensity values with moving window of 10 years. Value of 2023 calculated with IEA statistics comparing 2020 vs. 2010. Value of column "2030" refers to a moving window of 10 years based on 2023 (i.e. 2033 vs. 2023)*

7 *Clean hydrogen refers to blue and green hydrogen*

8 *Value of 2023 is zero as current production is mostly grey hydrogen.*

9 *Clean cooking refers to technologies using electricity, sustainable biomass, bioethanol (traditional biomass-based fuels not included).*

10 *Total system costs include investment in infrastructure (e.g. power plants and grids, manufacturing plants, charging stations), expenditure (acquisition costs of technologies in end-use sectors), and fuel costs (related to energy carriers for end-use sectors). Cumulative value per column refer as follows: 2030 column includes period 2025-2030, 2040 column covers period 2031-2040, 2050 column includes 2041-2050.*

Electricity access for the South America region is around 99% for almost all countries, according to ESMAP's SDG7 Tracking website. The energy modelling considers 100% access reached by 2030. BECCS = bioenergy carbon capture and storage; CCS = carbon capture and storage; $CO_2$ = carbon dioxide; EJ = exajoule; GW = gigawatt; $H_2$ = hydrogen; L = litres; Mt = million tonnes; TFEC = total final energy consumption; TPES = total primary energy supply; TWh/yr = terawatt hour per year.

## End-use sectors and energy efficiency

The energy transition in South America would benefit from a hybrid decarbonisation strategy. This would involve a combination of electrification and biofuel utilisation in end-use sectors, such as road transport, industrial processes and heating services for buildings.

Going forward, clean hydrogen is expected to make a modest contribution to overall consumption, mainly to decarbonising the regional iron, steel and fertiliser industries. In parallel, the further deployment of solar thermal energy (which includes solar PV and concentrated solar power [CSP]) for low-temperature processes would also contribute to the decarbonisation of demand-side applications. Under the DES, these deployments would raise the share taken by renewable energy (for both direct and indirect uses) from almost one-third of today's total final energy consumption (TFEC) to 40% in 2030 and over 80% in 2050. This would result in a decrease in energy intensity of almost 1% per year, reaching 3.7 megajoules (MJ) of primary energy supply per US dollar of GDP by 2050.

**Table S2** Key milestones in end-use sector energy transition (DES)

| | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|
| | **2030** | **2040** | **2050** |
| **TRANSPORT** | • 153 million vehicles (vs. 128 million units in 2023)<br>• 5% share BEVs of the total fleet (vs. 0.2% in 2023)<br>• 28% share flex-fuel vehicles of the total fleet<br>• 1.2 million charging points (vs. 0.1 million points in 2023)<br>• Electricity share: 1% in sector's TFEC (vs. 0.2% in 2023)<br>• Biofuels share: 18% in sector's TFEC (vs. 13% in 2023)<br>√ Introduction of clean hydrogen into cargo transportation<br>√ Blending ratios (volume) of biodiesel in the range of 10% - 20% and bioethanol range 10% - 30% | • >200 million vehicles<br>• >40% share BEVs of the total fleet<br>• 23% share flex-fuel vehicles of the total fleet<br>• 22 million charging points<br>• Electricity share: 15% in sector's TFEC<br>• Biofuels share: >25% in sector's TFEC<br>• Clean hydrogen share: <1% in sector's TFEC<br>√ Blending ratios (volume) of biodiesel in the range of 15% - 25%, bioethanol range 15% - 30% and SAF up to 40% | • 254 million vehicles<br>• >75% share BEVs of the total fleet<br>• 19% share flex-fuel vehicles of the total fleet<br>• 55 million charging points<br>• Electricity share: 45% in sector's TFEC<br>• Biofuels share: 35% in sector's TFEC<br>• Clean hydrogen share: <1% in sector's TFEC<br>√ Blending ratios (volume) of biodiesel in the range of 20% - 25%, green diesel up to 10%, bioethanol range 25% - 30% and SAF up to 80% |
| **INDUSTRY** | • Sector energy intensity of 15 MJ/USD (vs. ~16 MJ/USD in 2023)<br>• Electricity share: 24% in sector's TFEC (vs. 19% in 2023)<br>• Bioenergy share: 32% in sector's TFEC (vs. 28% in 2023)<br>√ Continue current energy efficiency measures (standards, labelling)<br>√ Introduction of clean hydrogen in specific subsectors | • Sector energy intensity of 15 MJ/USD<br>• Electricity share: 27% in sector's TFEC<br>• Bioenergy share: ~40% in sector's TFEC<br>• Clean hydrogen share: 1% in sector's TFEC (direct uses in iron, steel and chemicals production)<br>√ Introduction of CCS/BECCS in hard-to-abate sectors (*e.g.* cement, iron and steel) at end of decade | • Sector energy intensity of 14.6 MJ/USD<br>• Electricity share: 30% in sector's TFEC<br>• Bioenergy share: 46% in sector's TFEC<br>• Clean hydrogen share: 2% in sector's TFEC<br>• 800 Mt of cumulative captured $CO_2$ emissions through CCS/BECCS in the period 2040-2050<br>√ Increase of secondary production in main industrial processes (steel, aluminium, paper), up to 50% of total tonnage<br>√ Further substitution of coal and products in industrial processes with sustainable bioenergy, up to 50% |

| | | | |
|---|---|---|---|
| **BUILDINGS** | • Floor area of 77 million $m^2$ (vs. 69 million $m^2$ in 2023)<br>• Electricity share: 57% in sector's TFEC (vs. 51% in 2023)<br>• Bioenergy share: 13% in sector's TFEC, mostly traditional biomass (vs. 18% in 2023)<br>• Deployment of solar thermal energy (1% in TFEC) | • Floor area of 88 million $m^2$<br>• Electricity share: ~75% in sector's TFEC<br>• Bioenergy share: <10% in sector's TFEC (>5% - traditional biomass)<br>• Solar thermal energy share: 1% in sector's TFEC | • Floor area of > 98 million $m^2$<br>• Electricity share: >90% in sector's TFEC<br>• Bioenergy share: <5% in sector's TFEC (1% - traditional biomass)<br>• Solar thermal energy share: 2% in sector's TFEC |

**Notes:** Flex-fuel vehicles increase over time (in absolute terms), although share with respect to total fleet seems to decrease. BECCS = bioenergy with carbon capture and storage; BEV = battery electric vehicles; CCS = carbon capture and storage; $CO_2$ = carbon diorxide; $m^2$ = squared metre; MJ = megajoule; SAF = sustainable aviation fuel; TFEC = total final energy consumption; USD = US dollar.

## Power sector and infrastructure

South America's power sector is already undergoing a decisive shift towards renewables. Under the PES, these account for over 90% of the region's power generation by 2050, while under the DES, the figure is even greater, at 98%. This builds on the fact that South America is one of the richest regions in the world in terms of diversified, competitive and abundant renewable resources, such as hydropower, solar and wind. Indeed, while South America has had a long-standing reliance on hydropower, there has recently been a clear diversification in the generation mix, with solar and wind progressively displacing fossil fuels and covering growth in electricity demand.

Under the DES, around 1400 GW of additional renewable capacity is required over the 2025-2050 period, or around 55 GW per year. That is nearly 2.7 times the renewable rollout anticipated under the PES, which averages 20 GW each year. Solar and wind lead the expansion in both scenarios.

Going forward, South America's electricity consumption is expected to grow as the region develops and its population expands. In meeting this growing demand, the region's transition to an almost completely decarbonised power sector is not being shaped by expansion of renewable generation alone. It is also being supported by the removal of fossil fuels in end-use services and sectors, in addition to the energy sector. This further promotes electrification or green hydrogen utilisation. Together, these drivers are likely to raise the region's electricity needs, roughly two-thirds of the rise in electricity demand between 2030 and 2050 would also be driven by further electrification and hydrogen uptake.

While this growth facilitates deep decarbonisation across transport, industry and fuels, it also increases near- and medium-term power system investment needs. This is primarily due to the need for investment in new capacity, flexibility and infrastructure. These pressures are particularly acute in the "last mile" additions necessary to move from today's level of roughly 80% renewables in power generation to nearly 100% by 2050. Importantly, any analysis of this must account for the higher operating costs of fossil fuels, meaning that the case for renewables remains cost-effective overall. This requirement does need careful communication to policy makers, given the sensitivity of power tariffs in South America.

South America's energy transition requires substantial investments in storage, back-up capacity and new grid infrastructure to manage variability and maintain reliability. Hydropower has traditionally provided the flexibility necessary to balance the system, but long-term uncertainty around water resources and the heightened risk of droughts due to climate change mean that complementary sources of back-up will be essential. In this context, sources of dispatchable system flexibility can play an important role in reliability, offering security and the ability to support variable renewables while minimising the risk of supply shortfalls. Such sources include short duration and long duration energy storage, demand response and power generation from natural and renewable gases.

Crucially, co-ordinated planning and investment in cross-border interconnections and regional ancillary service markets can also play a significant role in reducing the pressures related to these investments. They can do this by allowing renewables to be shared across borders, minimising redundancy and lowering total system costs. In contrast, decentralised or nationally isolated strategies can increase costs, weaken efficiency and risk prolonging fossil fuel use. The key lesson is that with demand quadrupling, only integrated infrastructure planning that fosters grid expansion and modernisation – complemented by regional co-operation – can turn higher electricity requirements into a foundation for resilient, low-cost and sustainable growth across South America.

**Table S3** Key milestones in the power sector energy transition (DES)

| DECARBONISING ENERGY SCENARIO | | |
|---|---|---|
| **2030** | **2040** | **2050** |
| • +65 GW solar PV, +32 GW wind, +13 GW hydro (vs. a total installed capacity of 68 GW, 45 GW and 178 GW in 2024, respectively) | • 3× solar PV, 3.2× onshore wind, +10% hydro (vs. 2030) | • 2.3× solar PV, 1.7× onshore wind, +17% hydro (vs. 2040) |
| • 91% RE in generation by 2030 | • 97% RE in generation by 2040 | • 98% RE in generation by 2050 |
| • 58 GW distributed generation by 2030 (vs. a total installed capacity of 35 GW in 2024) | • 108.5 GW distributed generation by 2040 | • 237 GW distributed generation by 2050 |
| • Stronger regional interconnections for RE and hydro balancing | • Grid modernisation with advanced digitalisation | • Fully renewable, resilient grids via regional co-operation |
| • USD 345 billion T&D investment by 2030 (compared to an estimated USD 30 billion per year in recent years) (IADB, 2024) | • USD 1 039 billion T&D investment between 2031 and 2040 | • USD 1 847 billion T&D investment between 2041 and 2050 |
| • Energy storage to 11 GW (compared to approximately 1 GW total installed capacity in 2024) | • Energy storage to 76 GW capacity | • Energy storage to 229 GW capacity |

**Notes:** GW = gigawatt; PV = photovoltaic; RE = renewable energy; T&D = transmission and distribution.

## Bioenergy and fuel sector impact

Decarbonisation in South America is highly reliant on sustainable bioenergy. The DES reflects a major shift towards these resources, building on the region's favourable climate, land and water availability, and extensive agricultural base. Without this resource potential and existing market development, decarbonising the region would require costlier measures. In particular, it would require greater investment in additional power and hydrogen infrastructure for end uses, with these having to rely on these alternative types of energy.

Under the DES pathway, a substantial expansion in all forms of modern bioenergy is foreseen. Liquid biofuel output is projected to more than double, while by 2050, traditional biomass use falls by over 95%. This expansion includes measures such as intensive biofuels blending (bioethanol and biodiesel) and the deployment of flex-fuel vehicles in road transport. The DES also foresees the introduction of biofuel-based sustainable aviation fuels (SAFs) and the use of sustainable biomass as a substitute for coal and coke in energy-intensive industries such as cement and steel. In cooking and heating in buildings, the DES also foresees the replacement of traditional biomass with modern biomass and biomethane, with both being integrated into the natural gas grid.

In addition, the supply of bioethanol and SAF for international bunkering is seen as strengthening the region's export role. Indeed, this scale-up of bioenergy, as modelled in the DES, entails diversity in the types of biofuels and development of the corresponding infrastructure, bringing a positive impact to the region. This impact is not only in energy and environmental terms, either, but also in socio-economic development. Modern bioenergy is projected to account for more than one-third of TFEC by 2050, while also creating significant employment opportunities.

**Table S4** Key milestones in the bioenergy energy transition (DES)

| DECARBONISING ENERGY SCENARIO | | |
|---|---|---|
| **2030** | **2040** | **2050** |
| • 43 billion L of bioethanol (vs. ~30 billion L in 2023) | • 66 billion L of bioethanol | • 82.5 billion L of bioethanol |
| • 20 billion L of biodiesel (vs. 9.5 billion L in 2023) | • 21 billion L of biodiesel | • 14 billion L of biodiesel |
| • 3 billion $m^3$ biogas/biomethane | • 16 billion $m^3$ biogas/biomethane | • 30 billion $m^3$ biogas/biomethane |
| • 6.3 EJ of bioenergy supply (vs. 4.6 EJ in 2023) | • 10 EJ of bioenergy supply | • 13 EJ of bioenergy supply |
| • Share of 20% in TFEC (vs. 16% in 2023) | • Share of >25% in TFEC | • Share of 33% in TFEC |
| • Share of 4% in electricity generation (vs. 5% in 2023) | • Share of ~3% in electricity generation | • Share of 2% in electricity generation |
| | | • 420 Mt of cumulative captured $CO_2$ emissions in period 2040-2050 |

**Notes:** Bioenergy use in electricity generation increases in absolute values in both installed capacity and generation over study period, although shares seem to reduce. $CO_2$ = carbon dioxide; EJ = exajoules; L = litres; $m^3$ = cubic metres; Mt = million tonnes; TFEC = total final energy consumption.

## Hydrogen and derivatives

South America could play an important role in global clean hydrogen production, supported by abundant renewable energy resources, national strategies that mainly target hydrogen exports and ongoing regional certification initiatives. Indeed, regional production of clean hydrogen and its derivatives, particularly ammonia, could reach 22 Mt, or around 4% of the total global estimated clean hydrogen production, according to IRENA's *World energy transitions outlook 2024* analysis (IRENA, 2024a). These products would be used mainly in maritime transport and bunkering. Combined with domestic uses, hydrogen and its derivatives are also expected to support industrial decarbonisation in sectors such as iron and steel and chemicals (mainly fertilisers), with only a limited amount being blended into the natural gas grid. This pathway, however, creates significant additional electricity needs. By 2050, these would have added around 1 300 TWh to end-use sector demand for electricity.

Finally, current oil and gas infrastructure may also play a role in supporting green hydrogen production. This would be either to meet internal demand – contributing to businesses' decarbonisation goals – or by re-directing the uses of land, infrastructure and labour for on-site production.

**Table S5** Key milestones in the hydrogen and derivatives energy transition (DES)

| DECARBONISING ENERGY SCENARIO | | |
|---|---|---|
| **2030** | **2040** | **2050** |
| • Production of 0.33 EJ in clean hydrogen (~3 $MtH_2eq$) | • Production of 1.3 EJ in clean hydrogen (~11 $MtH_2eq$) | • Production of 2.7 EJ in clean hydrogen (~22 $MtH_2eq$) |
| • Electrolyser capacity of 32 GW | • Electrolyser capacity of 130 GW | • Electrolyser capacity of 260 GW |
| • Hydrogen demand: 0.7 EJ (~6 $MtH_2eq$), with 3 Mt exported | • Hydrogen demand: 1.8 EJ (~15 $MtH_2eq$), with 9 Mt exported | • Hydrogen demand: 2.9 EJ (24 $MtH_2eq$), with 17 Mt exported |

**Notes:** Clean hydrogen refers to blue and green type. Production of hydrogen in 2023 corresponded to 0.25 EJ (~2 $MtH_2eq$), mostly fossil-fuel based. EJ = exajoules; $H_2eq$ = hydrogen equivalent; GW = gigawatt; Mt = million tonnes; PJ = petajoules.

## Pathways to implementation

In South America, implementing energy transition roadmaps and fully harnessing their benefits requires a strengthening of six key factors: regional strategy, governance, skills, finance, infrastructure and energy planning.

- **Regional strategy:** This involves a range of sectors, with energy transition plans increasingly becoming part of broader sustainable development programmes involving all sectors of the economy. Indeed, it is not only the energy sector that is undergoing a transformation, but industrial sectors are required to change the way they produce goods and services, modes and technologies, too. Strategy must involve rethinking mobility services as well as cities, ports, airports, roads and education. A holistic approach is crucial to align the needs of regional and domestic infrastructure with long-term sustainable development requirements.

- **Governance:** Adjustments to institutions and domestic policies are required to foster the energy transition and unlock the potential of sustainable development at the regional level. Effective co-ordination among different countries and sectors requires harmonised policy making, along with enforcement of mechanisms and conflict resolution frameworks.

  As an example, South America would benefit from a joint strategy for critical minerals and rare earth exploitation. It would also benefit from a joint strategy for the development of the renewables supply chain and for a common certification system for sustainable fuels. These measures could strengthen regional competencies and enhance South America's negotiating power in global trade. In addition, fiscal and tax policies – such as fiscal reallocation from fossil fuel subsidies and fair pricing mechanisms – can be decisive in shaping the pace of the energy transition. It is not the selection of fuels that drives the energy transition, but the decision to enable consumers to choose efficient and renewable-based goods.

- **Skills:** The new sets of competencies required and the jobs created by the energy transition and its cross-sector multiplier effect could help reduce South America's rates of unemployment and enhance its prosperity. Capacity building policies are required for innovation, the expansion of renewables manufacturing, sustainable fuels, the development of minerals and critical materials, and the enhancement of policy making, planning and regulation. These policies should seek to foster the new skills and competences required by human capital to underpin a fair and inclusive energy transition, aligned with multi-sector transformation.

- **Finance:** The shared global responsibility of addressing climate change requires a global financial commitment, as well as equitable risk-sharing mechanisms. A higher cost of capital remains a barrier to infrastructure project development, including in energy and grids. Regional innovative financial frameworks could help South American countries access lower-cost finance, drawing on successful local cases and leveraging support from the international community. Joint finance strategies may also benefit from exchanges of best practices on managing and planning for the decline on oil and gas production and consumption, including managing the impact on fiscal budgets and tax adjustments.
- **Infrastructure**: Strategic investments in transport and energy grid projects can foster the competitiveness of the region and lower energy costs. Renewable energy potential, critical materials and manufacturing capabilities are unevenly distributed across South America. The effective integration of variable renewable energy (VRE) requires investment in storage solutions, grid modernisation and innovative planning. The cost of energy transition goods can be reduced by a more efficient regional logistics system. Moreover, existing infrastructure – including ports, airports and railways – should be upgraded to facilitate the export and import of key energy transition goods.
- **Energy planning**: Innovative approaches to energy planning are key to ensuring energy security, affordability, resilience and community empowerment. Planning processes must cope with climate change uncertainties, the geopolitical dimensions of the energy transition and the integration of new digital and artificial intelligence (AI) functionalities. They also need to properly address emerging demands for energy, such as those from electric vehicles (EVs), hydrogen production and data centres. This must also be done while managing the VRE profiles of solar and wind alongside flexibility solutions such as storage, sector coupling and digitalisation. In the power system, stronger co-ordination between system operators and energy transition plans will be needed. Equally importantly, placing people at the centre of planning processes implies engaging communities and incorporating their knowledge and aspirations in order to yield inclusive and equitable outcomes.

## Implementing a regional action plan

In order to help strengthen the key success factors outlined above, IRENA proposes seven regional energy-focused actions to advance in the implementation of the DES pathway. These seek to achieve that goal while boosting investments in South America and leveraging South America's comparative advantages. The seven actions are:

**1**

**Establish regional frameworks and mechanisms to reduce the cost of capital and mitigate risks for sustainable infrastructure investments.**

USD 13 trillion is required to finance the region's energy transition during the 2025-2050 period under the DES. According to IRENA's *Renewable power generation costs in 2024* report, the share of financing in the LCOE increases with higher weighted-average cost of capital (WACC) (IRENA, 2025a). For instance, WACC values for certain countries in South America in 2024 ranged between 8% and over 15%, with the share of finance in LCOE ranging from around 50% to 70%.

**2**

**Advance the implementation of an integrated regional electricity market, supported by co-ordinated grid planning and harmonised auction mechanisms.**

Electricity demand across South America is set to multiply by four times over the coming decades, with installed capacity needing to expand even more in order to meet this increasing demand. Without co-ordination of capacity reserves, the region could reach average efficiency losses in the order of USD 1 billion per year for each year out to 2050. Beyond capacity reserves, a single regional market would deliver even greater savings, supported by shared auction mechanisms and joint grid planning. The Energy Integration System of the Southern Cone Countries (*Sistema de Integración Energética de los Países del Cono Sur* – SIESUR) and the Andean Electrical Integration System (*Sistema de Interconexión Eléctrica Andina* – SINEA), for instance, are already promoting further integration and taking action towards a regional market. Regional integration and projects could also benefit from common principles of environmental and sustainable governance.

**3**

**Set up a regional solar and wind supply chain plan.**

By 2050, South America is expected to need some 1 240 GW of additional solar and wind power generation capacity – equivalent to 48 GW of annual additions. This scale of deployment creates the opportunity to expand and/or build industrial hubs around clean energy technologies. Developing regional manufacturing for transition-related equipment such as turbines, panels and critical components would lower costs, reduce dependence on technology imports and speed up implementation of the transition. It would also mean new skills and new jobs spread across the region. With the right planning, South America can become not only a leader in renewable deployment, but also a key supplier to the global clean energy economy.

**4**

**Co-ordinate green hydrogen production.**

By 2050, regional production of hydrogen is expected to stand at around 22 $MtH_2eq$. This would be around 4% of total global estimated clean hydrogen production, according to IRENA's *World energy transitions outlook 2024* analysis (IRENA, 2024a). Hydrogen would be for export, via derivatives such as ammonia and for local consumption in hard-to-abate sectors. It is important to acknowledge that such projections depend greatly on uncertainties in global demand and evolving technologies. South American countries are currently racing to release plans and frameworks for hydrogen production with the aim of becoming regional leaders or hubs. A more co-ordinated approach among countries could tap the best available natural resources, facilitate access to cheaper finance, support the development of a local supply chain and help the development of the infrastructure planning necessary to bring production to market.

## 5

**Develop and implement regional green industrialisation strategies, including critical minerals, sustainable metals and resilient logistics corridors.**

The impact of the energy transition goes beyond the energy sector. It will require an expansion in the production of transition-related goods. These include EVs, more efficient equipment, sustainable fuels (including biofuels and hydrogen and its derivatives), low-carbon products, green steel, green fertilisers, critical minerals and materials. Green industrialisation offers South American countries the opportunity to rationalise and split the supply chain across the region. At the same time, countries can develop strategic logistics corridors that can connect producers to consumption centres or export hubs.

## 6

**Develop a sustainable, co-ordinated regional biofuel strategy to optimise the retrofitting of existing fossil fuel assets and strengthen fuel supply security.**

When both biodiesel and bioethanol are taken into account, the scaling up of biofuels is expected to see production reach around 97 billion litres (L) by 2050. That is an increase of almost 2.5 times the current level. This increase will be driven by increases in consumption in road transport, aviation and shipping, as well as by the use of SAF and bunkering exports. At the same time, under the DES pathway, pipelines for oil and gas transmission and distribution, as well as oil refineries, will face declining fossil fuel consumption. Compared to current levels, around 30% less fossil fuel will be consumed by 2040 and over 70% less by 2050. Expanding or retrofitting assets for renewable fuel utilisation may be economical, while a co-ordinated process of renewable fuel supply would assure security and affordability. Co-operation among countries in co-ordinating renewable fuel security in the region would be highly beneficial.

## 7

**Create a regional hub for energy efficiency and material efficiency.**

Under the DES, cross-sector policies that promote better use of energy and materials while reducing waste production could decrease $CO_2$ emissions in 75% by 2050, compared to the 2023 base year (around 80% less compared to PES-2050 level). A significant proportion of regional energy costs and greenhouse gas (GHG) emissions come from inefficiencies, such as outdated appliances, inefficient technologies, inadequate building envelopes and ageing vehicle fleets. These exist alongside material inefficiencies due to highly intensive resource-use in manufacturing and food and water production, as well as insufficient recycling of materials and plastics. Establishing a regional hub would enable countries to align good practices, harness innovation and scale-up efficiency measures across all sectors.

# INTRODUCTION

South America is well positioned to harness its competitive energy transition resources. It is also well placed to play an important role in global efforts related to sustainability, energy security and climate change, as encompassed by the goals of the Paris Agreement. Mobilising investment in clean energy and green industrialisation – including investment in the development of regional value chains – presents a strategic opportunity for the region to scale up sustainable socio-economic benefits.

The *World energy transitions outlook 2024* produced by IRENA highlights the significant acceleration needed across energy sectors and technologies if the world is to fulfil the goal of the Intergovernmental Panel on Climate Change (IPCC) to limit global warming to no more than 1.5°C above pre-industrial levels by the end of the century (IPCC, 2022a). This acceleration entails a range of initiatives, from enabling deeper end-use electrification to increasing the use of sustainable fuels, renewable heat solutions, energy efficiency and infrastructure additions.

Under the Planned Energy Scenario (PES), global annual carbon dioxide ($CO_2$) emissions remain at 36.5 gigatonnes (Gt) by 2050. In contrast, IRENA's 1.5°C Scenario[2] outlines a pathway to achieve net-zero emissions by mid-century. As the energy sector accounts for around 80% of global anthropogenic $CO_2$ missions, it is central to this transformation, and requires urgent and co-ordinated action across multiple fronts. A significant shift in how the energy is produced, delivered and consumed is at the heart of this global transformation, supported by new supply chains, resources, services, infrastructure and trade routes. IRENA's 1.5°C Scenario estimates more than USD 150 trillion of energy transition investments being made by 2050. Globally, all regions and economic sectors must therefore embrace the challenge and the opportunities presented by scaling up sustainable development solutions.

Moreover, at the Conference of the Parties (COP28) in 2023 all 198 parties present agreed to triple renewable energy capacity and double energy efficiency by 2030. This goal became a central part of the UAE Consensus and IRENA was subsequently assigned the task of monitoring its progress (IRENA, 2024b). Further commitments and declarations on sustainable development, energy transition and climate action then took place in November 2024 during the Group of 20 (G20) meeting in Rio de Janeiro (European Commission, 2024).

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[2] *Although the Decarbonising Energy Scenario (DES) used in Regional Energy Transition Outlooks (RETOs) does not align fully with the global net-zero timeline outlined in the 1.5°C Scenario presented in the World Energy Transitions Outlook (WETO), it remains consistent with the global objective of limiting temperature rise well below 2°C and within reach of 1.5°C by the end of the century.*

Following that – and in partnership with IRENA – the Brazilian government held the Energy Planning Summit in June 2025. This saw the establishment of the Global Coalition for Energy Planning (GCEP), which has the aim of bridging the investment gap in the clean energy transition through enhanced energy planning (Energy Monitor, 2025). This coalition served as a crucial step towards a successful COP30 in Belém, Brazil in November 2025, supporting the COP30 presidency's Global Climate Action Agenda. That agenda reaffirms the commitment agreed upon at COP28 to implement the outcomes of the Paris Agreement Global Stocktake (COP30 Brasil, 2025). Part of IRENA's contribution to this initiative, in its role as the Global Coalition for Energy Planning (GCEP) Secretariat, is this series of regional energy transition outlooks (RETOs), including this report on South America.

South America holds some of the world's most cost-competitive renewable energy resources, as highlighted in IRENA's *Renewable power generation costs in 2024* (IRENA, 2025a). In addition to these renewable energy options, the region also has a diverse mix of fossil fuel resources, with natural gas continuing to expand its role – sometimes described as an "energy transition carrier" (IDB, 2020a). Furthermore, South America is richly endowed with many of the minerals essential for the global energy transition, including significant reserves of lithium, copper and silver, among others (OLADE, 2024a).

At the same time, the region is already well above the global average in renewable energy production and consumption. According to the countries' energy balances published by national energy-related institutions, the share of renewable energy in the region with respect to its total energy supply was 36% in 2023, compared to the global average of 14% (IRENA, 2024a). Various initiatives are also already underway in the region that foster the energy transition. These include:

- Renewables in Latin America and the Caribbean (*Renovables en Latinoamérica y El Caribe* – RELAC), which works in the power sector and has the Inter-American Development Bank (IDB) as its technical secretariat.
- The Latin American Energy Organisation (*Organización Latinoamericana de Energía* – OLADE).
- The Economic Commission for Latin America and the Caribbean (ECLAC).
- The Regional Forum of Energy Planners (*Foro Regional de Planificadores Energéticos* – FOREPLEN).
- The Platform for the Development of Green Hydrogen in Latin America and the Caribbean (*Plataforma para el desarrollo del hidrógeno verde en Latinoamérica y el Caribe* – H2LAC).

In addition, there are other regional economic blocs and political fora that foster integration, such as the Community of Latin American and Caribbean States (*Comunidad de Estados Latinoamericanos y Caribeños*) the Andean Community of Nations (*Comunidad Andina*) and the Southern Common Market (*Mercado Común del Sur* [MERCOSUR]). Nevertheless, energy transition planning is currently still carried-on predominantly on a state-by-state basis within national borders.

At present, South America does not attract sufficient investment for the energy transition. In 2024, the region received USD 58 billion – just 2.5% of the global total of USD 2.4 trillion. Nevertheless, some countries in the region have attracted considerable investment in renewable energy, as shown in Chapter 1 (section 1.5). In Brazil, for example, the National Bank for Economic and Social Development (*Banco Nacional de Desenvolvimento Econômico e Socia*l [BNDES]) invested around USD 100 billion in renewable energy projects (new power capacity and transmission lines) over the period 2000-2023, making the bank a leading international financial institution, according to BloombergNEF (IRENA and BNDES, 2024).

In 2023, South America was home to around 439 million people (5.4% of the global population), with a regional gross domestic product (GDP) of nearly USD 5.3 trillion (CE, n.d.). Based on the data countries provided for this study, the region's population would increase to 491 million by 2050, while regional GDP will almost double, growing at a compound annual growth rate (CAGR) of 2.4% between 2023 and 2050 (Table I1).

**Table I1** Regional estimated population and GDP, 2023-2050

| SOUTH AMERICA | 2023 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Population (million) | 439 | 460 | 481 | 491 |
| GDP[1] (USD billion[2]) | 5 276 | 6 103 | 7759 | 9 867 |
| GDP per capita (USD[3] per capita)[4] | 12 007 | 13 271 | 16 144 | 20 114 |

**Source:** (CE, n.d.).

**Notes:** [1] gross domestic product (GDP) in market exchange rate (MER); [2] In 2024 USD; [3] In 2024 USD; [4] In 2023, the Gini coefficient ranges between 40.7 and 53.9 in 2023 for the South American region (World Bank, n.d.a).

Currently, the region has a lower per capita GDP than that of developed countries, or the global average. In 2023, South America's GDP per capita was USD 12 007, while the global average was USD 13 700 and the European Union (EU) figure was USD 46 500 (CE, n.d.). The region's energy consumption per capita was also around 66% of the G20 value and 35% of the EU level that year. In terms of access to clean cooking technologies, in 2023 more than 20 million people in South America had no access to these, according to *Tracking SDG7: The energy progress report 2025* (IEA, *et al.*, 2025). Regarding affordability, in 2020, households in Latin America (which includes South America) spent an average of around 8% of their income on energy, with this including the cost of fuel for transportation and for domestic consumption (IDB, 2020b). Moreover, energy prices had a greater impact on the daily costs of low-income households than on high-income ones. This reaffirmed the importance of SDG7, which seeks affordable and clean energy and a just energy transition for all.

According to the latest ECLAC publication, the Latin America and the Caribbean subregion is expected to achieve some 24% of the SDG goals by 2030 (ECLAC, 2025). Some 37% of the SDG goals have stalled or regressed, however, indicating a risk of the subregion failing to fulfil the 2030 Agenda (ECLAC, 2025). With SDG7, though, Latin America and the Caribbean have already reached most of their targets. However, SDG7a – which refers to international co-operation in facilitating access to clean energy research and technology, as well as to promoting investment in associated infrastructure – has seen progress in the right direction, albeit at a pace too slow to be accomplished by 2030.

Meanwhile, the energy transition and integrated regional planning represent a great opportunity – not only for the fulfilment of SDG7, but also for supporting other goals. "Affordable and clean energy" can power the infrastructure needed for agriculture and nutrition, healthcare, education, water processing, communities, mobility and business, while also securing positive planetary and social outcomes (SEforALL, 2024).

South America's energy transition is also taking place against a backdrop of growing exposure to climate risk and structural socio-economic challenges. The region is among the world's most vulnerable to the impacts of climate change, with six of its countries ranking among the 50 most affected globally (David Eckstein, 2021). Those six are: the Federative Republic of Brazil, the Plurinational State of Bolivia, the Republic of Chile, the Republic of Colombia, the Republic of Paraguay and the Republic of Peru. Recent years have underscored this vulnerability: in 2023, the Republic of Ecuador faced severe electricity shortages linked to the worst drought in 50 years, combined with surging demand and delays in non-hydro generation commissioning.

This forced the government to impose rationing and later declare a national emergency in the sector. Similarly, Brazil has been experiencing extreme weather events, including major droughts in the Amazon and devastating floods in Rio Grande do Sul, while widespread forest fires have affected several critical biomes.

Several structural factors are also shaping the region's energy transition pathway. Low per capita income levels, coupled with persistent income inequality, constrain the ability of households and governments to absorb transition costs. At the same time, the region holds significant reserves of critical minerals, positioning it as a potential leader in global supply chains for clean energy technologies, but also exposing it to governance and environmental risks. In addition, the region has a history of economic instability which may complicate investment perspectives, particularly for capital-intensive and long-term infrastructure projects.

The current dependence of many South American economies on fossil fuels presents an additional challenge related to fiscal budgets. Transitioning and diversifying toward low-carbon energy sources other than hydropower – which the region already relies largely on – will require not only shifting technologies, but also the management of significant socio-economic impacts. Fossil fuel revenues remain a crucial source of funding for local governments and social programmes; phasing out extractive industries could therefore strain public finances and exacerbate regional inequalities, if not carefully managed. Fiscal reform, employment transition strategies and measures to eliminate fossil fuel subsidies will be critical in ensuring a just and sustainable regional energy transition.

The aim of this study is to contribute to the regional and country debate on how South America can explore the opportunities and benefits, as a region, of the global energy transition. The pathways presented in this study may serve policy makers, energy planners, government institutions, regional entities and private stakeholders as technical guidance in support of the elaboration, revision and/or implementation of energy plans, Nationally Determined Contributions (NDCs), long-term climate strategies, national mitigation strategies, investment plans and other energy transition matters.

Furthermore, as mentioned above, this study also aims to inform ongoing discussions and initiatives in South America related to the energy transition, regional integration and energy planning co-operation. Such initiatives include RELAC, OLADE's energy planning council, ECLAC's energy planner's forum, SIESUR and SINEA.

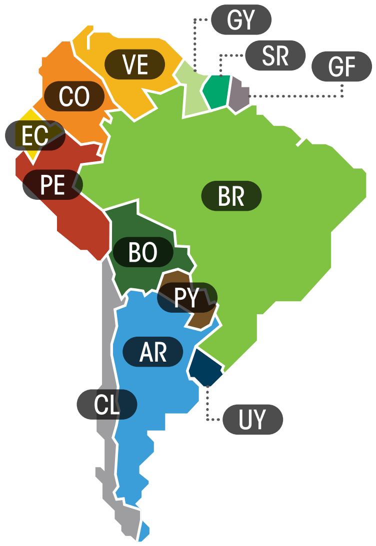
The RETOs are also part of an IRENA programme that aims not only to feed into the agency's WETO analysis. It also aims to provide the granularity required when it comes to the characteristics of available resources, infrastructure and economic sector specificities, and the socio-economic endowments of each region and country. This is the second IRENA outlook for the Latin America and the Caribbean region, following the agency's 2022 Central America analysis (IRENA, 2022a). IRENA has also completed other regional projects covering the Association of Southeast Asian Nations (ASEAN) and the EU. The agency is also currently concluding a study of African sub-regions to be published in 2026.

This study for South America evaluates the degree of integration of renewable and low-carbon technologies into the supply-side and end-use sectors of 13 South American countries (Figure I1). It also features detailed power sector modelling, as well as modelling of key technologies such as hydrogen and its derivatives, and bioenergy.

This outlook also includes a policy assessment identifying current initiatives and recommending enablers for the measures proposed in the scenarios – particularly for those that support an ambitious decarbonisation aiming net-zero or near to zero emissions by 2050. In addition, the study evaluates the socio-economic consequences of transition pathways – at different levels of ambition and around the region – in terms of GDP, employment and welfare.

A crucial part of the RETO project is the engagement process. Throughout the different stages of the project, scenario development involved several multilateral and bilateral meetings – virtual, hybrid and on-site. These were held with regional entities as well as country-based representatives and energy specialists. Sessions with country bodies, along with regional institutions such as OLADE, ECLAC, SIESUR and the IDB, were also held. These provided a range of visions and strategies for the decarbonisation of the region's energy sectors, while also respecting country context. They also validated the input parameters of the modelling tools and the assumptions behind the scenarios. In addition, they identified data and information gaps while supporting ongoing analysis and elaboration of studies and national energy plans, providing feedback to the stakeholders.

**Figure I1** South American countries included in the report

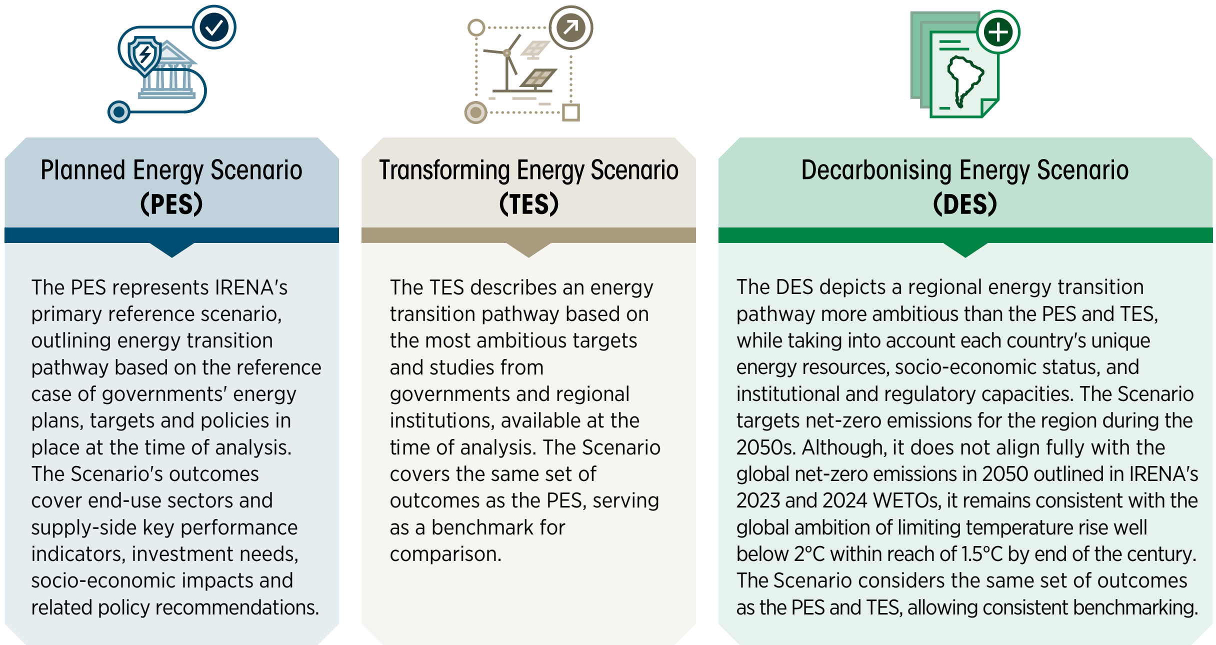



| | |
|---|---|
| **AR** | Argentina |
| **BO** | The Plurinational State of Bolivia |
| **BR** | Brazil |
| **CL** | Chile |
| **CO** | Colombia |
| **EC** | Ecuador |
| **GF** | French Guiana |
| **GY** | Guyana |
| **PY** | Paraguay |
| **PE** | Peru |
| **SR** | Suriname |
| **UY** | Uruguay |
| **VE** | The Bolivarian Republic of Venezuela |

**Disclaimer:** This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

In terms of the energy modelling, the analysis was carried out by country and included three energy scenarios for the 2023-2050 study period. As described in Figure I2, the three were the Planned Energy Scenario (PES), the Transforming Energy Scenario (TES) and the Decarbonising Energy Scenario (DES). To analyse the end-use sectors, a bottom-up approach was implemented using the in-house Renewable Energy Roadmap (REmap) Activity Tool, with detailed analysis by sector and selected subsectors and services, depending on the context of each country. The power sector capacity expansion and short-term operational analysis was modelled in PLEXOS, based on an extensive, detailed analysis and engagement process with the countries of the region. The starting point for this was a model utilised by IDB for The Grid of the Future (La Red del Futuro) (Paredes, 2017). The full energy assessment of the region was complemented by an analysis of investment needs in infrastructure, as well as the expenditure associated with various technologies in the end-use sectors. It was also complemented by an analysis of expenditure in the consumption of the energy types, with this following price trends adjusted according to each scenario.

**Figure I2** Scenarios in the South American RETO study




This report includes the energy assessment, investment, costs and emissions results for the end-use and supply-side sectors. It also includes a comprehensive analysis of the policy enablers for each sector and the socio-economic impacts of the energy transition roadmaps. The socio-economic analysis was conducted using a macro-econometric model (E3ME)[3] that integrates the energy system and global economies into a single quantitative framework. The model sheds light on the trade-offs between economic prosperity and employment, while examining welfare aspects, including the distributional implications of policy choices. This report assesses the socio-economic differences between the PES and the DES. It will compare the outcomes of current national plans and policies in the PES with IRENA's proposed pathway towards deep decarbonisation in the DES. Findings from the TES are highlighted only in selected cases, as only a limited number of countries provided alternative scenarios that could provide guidance for the modelling.

This report is structured as follows: *Chapter 1* provides an overview of South America's current progress in the energy transition, presenting key energy indicators, total system costs and emissions results across the scenarios. It is also complemented by cross-sectoral policies for both energy demand and supply. *Chapters 2, 3 and 4* focus on the main end-use sectors – transport, industry and buildings. Each chapter describes the sector's current status in the region, presents transition roadmaps with key performance indicators (KPIs), and assesses their implications emissions and system costs - including infrastructure investment, as well as technology and fuel expenditures. Policy enablers specific to each sector are also identified.

The subsequent chapters address the supply side. They provide an overview of the region's resource potential, the infrastructure expansion required, the investment needs and the impact on emissions, followed by targeted policy recommendations. *Chapter 5* examines the regional power sector, presenting long-term capacity expansion and generation results, as well as sensitivity analyses under the DES to assess the role of specific technologies and grid configurations. *Chapters 6 and 7* analyse two key energy carriers for the region: bioenergy and hydrogen, detailing their potential contributions and integration pathways.

Finally, *Chapter 8* presents the socio-economic analysis for South America to 2050, outlining the potential impacts on GDP, employment and welfare. It also discusses the underlying drivers shaping these results.

*3 In this report, the E3ME global macro-econometric model (www.e3me.com) was used for the assessment of socio-economic impacts. Energy mixes and related investment, based on the REmap Activity Tool, were used as exogenous inputs for each scenario, as well as for climate related and transition related policies.*

# 01

# SOUTH AMERICA'S ENERGY TRANSITION PATHWAYS

## KEY INSIGHTS AND RECOMMENDATIONS FOR THE REGION

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ The energy transition has the potential to drive sustainable development across South America, advancing progress toward the SDGs and positioning the region as a global leader in decarbonisation. Under the Decarbonising Energy Scenario (DES), emissions are reduced by around 75% by 2050 compared with 2023 levels, achieving near net-zero emissions, universal access to clean energy by 2030, 2–3.1 million renewable energy jobs by 2050 and one of the world's lowest energy intensities. A diversified energy mix, coupled with deeper regional integration will enhance energy security and resilience, enabling the region to achieve with zero net energy imports by mid-century. | ★ Develop or update national and regional decarbonisation roadmaps with clear sector targets, timelines and monitoring mechanisms. Strengthen regional co-operation for integrated power markets, cross-border grids and clean energy supply chains. |
| ★ South America's transition will centre on renewable electrification, biomass use, and energy efficiency, supported by regional interconnection, modernised grids and the scale up of sustainable fuels for both domestic and export markets. | ★ Prioritise renewable electrification and cross-sector integration across power, transport, industry, buildings. Align planning for grid expansion, regional interconnectors and sustainable fuels such as advanced biofuels and e-fuels. |
| ★ Achieving the DES will require USD 13 trillion between 2025 and 2050 in South America. | ★ Mobilise public and private finance through blended mechanisms, risk-sharing models, and regional investment platforms. Engage national development banks to attract international capital and optimise guarantee instruments. |
| ★ Electricity generation is projected to double by 2050 under current plans and quadruple under the DES, driven by electrification and green hydrogen production. Electricity consumption per capita rises by over 3.5% annually, reaching more than 6 megawatt hours (MWh) per person by 2050. | ★ Support sector coupling between green hydrogen, electrified heating, and Vehicle-to-Grid (V2G) systems. Modernise and expand grids for flexibility and resilience. Reform markets to value storage, demand response, and digitalisation. |
| ★ Renewables could supply nearly 100% of electricity generation by 2050, with total installed renewable capacity reaching five times 2024 levels (around 312 gigawatts [GW]). Annual additions of about 55 GW (33 GW solar PV, 15 GW wind) will be needed. | ★ Accelerate renewable deployment through regional targets and streamlined permitting. Phase out coal and oil generation, promote flexibility measures, and expand storage capacity to maintain system reliability. |
| ★ The share of renewables in total final energy consumption would exceed 80% by 2050 under the DES (driven by a high share of modern bioenergy), consistent with IRENA's 1.5°C Scenario. | ★ Establish long-term bioenergy strategies with co-ordinated policies across industry, forestry, agriculture, and energy. Introduce mandates and blending obligations, and support R&D for advanced biofuels and sustainable biomass applications. |
| ★ Energy efficiency improvements will reduce regional energy intensity by about 1% per year by 2050, lowering consumption and emissions. | ★ Implement stringent efficiency standards, mandatory performance requirements, and demand-side management programmes (smart metering, demand response). Expand research and development (R&D) funding to accelerate innovation across all sectors. |
| ★ The DES envisions around 22 million tonnes (Mt) of clean hydrogen (mostly green) production by 2050 (over 75% dedicated to export markets), adding around 1 300 terawatt hours (TWh) to electricity demand – around 25% of total generation. | ★ Develop national and regional green hydrogen roadmaps, including port and airport infrastructure. Set procurement targets, support hydrogen hubs (*e.g.* Pecém, Piauí), and introduce incentives for early deployment and market creation. |

| | |
|---|---|
| ★ Carbon capture and storage (CCS) and bioenergy with CCS (BECCS) will be essential for residual emissions from hard-to-abate industries, allowing a cumulative capture of over 1 gigatonne (Gt) carbon dioxide ($CO_2$) by 2050. | ★ Develop carbon management strategies, fund research and development (R&D) and pilot projects, and invest in the transport of $CO_2$ and long-term storage infrastructure. |
| ★ Access to affordable finance remains a major challenge across South America, limiting investment in grid expansion, biofuels, hydrogen and industrial decarbonisation. | ★ Expand green finance instruments (green bonds, blended finance, public-private partnerships [PPPs]). Strengthen de-risking instruments, co-ordinate public funding, establish regional investment platforms, and promote cross-border co-operation to mobilise large-scale capital. |
| ★ Coherent cross-cutting policies – including carbon pricing, innovation, and workforce development – can accelerate the transition across all sectors. | ★ Establish carbon pricing mechanisms (*e.g.* emission trading systems [ETS] and carbon taxes) and promote the integration of regional carbon markets. Support R&D, innovation networks, and technology transfer. Invest in workforce reskilling and ensure a just transition. |

While giving consideration to the region's particular energy and socio-economic context, this chapter showcases the main outcomes of the assessment of South America's decarbonisation pathways.

It provides an overview of the region's current progress in the energy transition, along with the energy indicators and proposed roadmaps. The analysis compares total system costs and emissions across scenarios. It highlights cross-sectoral policies relevant to both supply and demand.

In addition, the chapter raises several guiding questions to inform and support policy makers.

Those questions include the following:

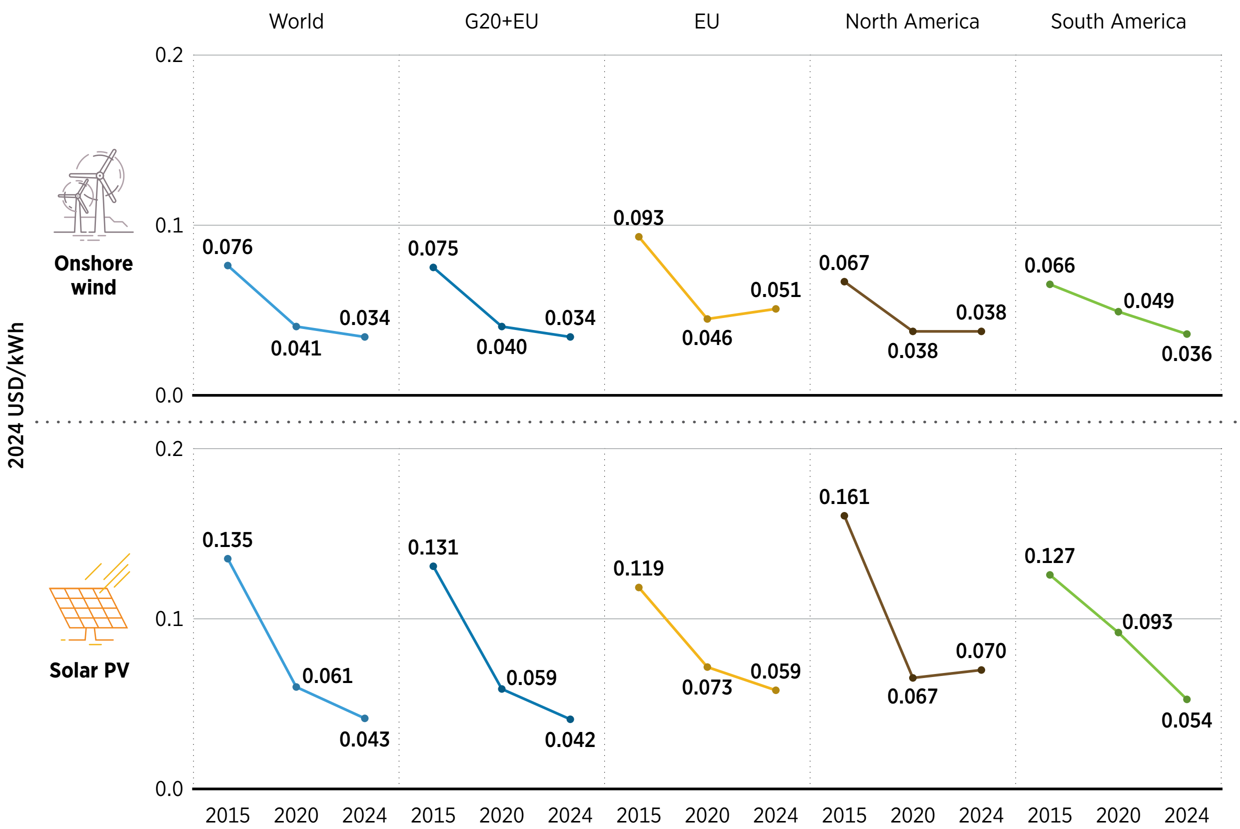
- Based on the existing directives and plans, how will South America's energy mix and emissions evolve in the short- and long-term?
- Which sectors will drive economy-wide decarbonisation and where do the main gaps remain?
- What role will trade have, and how can the region benefit from the expanding global green economy?
- How much investment is required per year under each energy transition pathway?
- What are the respective roles of renewable electrification and the direct use of renewables, particularly bioenergy, in end-use sectors?
- How are countries advancing strategies to integrate hydrogen into national energy systems and to develop frameworks for hydrogen trade and commercialisation at regional and global levels?
- To what extent are South American countries collaborating to establish a co-ordinated framework for integrated energy planning and policy alignment?

## 1.1 EMISSION REDUCTION: GLOBAL CHALLENGES AND SOUTH AMERICA'S STRATEGIC POSITION

According to the Global Carbon Project (GCP) in its 2025 edition of the Global Carbon Budget (GCB), South America's $CO_2$ emissions accounted for approximately 3% of total global emissions in 2023 (Global Carbon Project, 2025). That year, the region's per capita emissions were 2.5 tonnes of $CO_2$ ($tCO_2$), well below the global average of 4.7 $tCO_2$, and significantly lower than the levels in the EU (5.6 $tCO_2$) and the United States (14 $tCO_2$). While this does not exempt South America from contributing to global climate action, it helps contextualise and enhance understanding the region's position and the distribution of responsibility for the costs of the global energy transition.

At the same time, South America hosts some of the world's most abundant renewable energy resources and competitive renewable energy resources. According to IRENA's *Renewable power generation costs in 2024* report, Brazil (along with China) recorded the lowest costs for onshore wind facilities that year, at USD 0.030 per kilowatt hour (kWh) (IRENA, 2025a) (Figure 1.1). The region's countries also have some of the world's lowest cost large hydropower plants (IRENA, 2025a). South America can therefore be a global hub for cost-competitive emissions reductions.

**Figure 1.1** LCOE trajectories of variable technologies in selected regions, 2015-2024

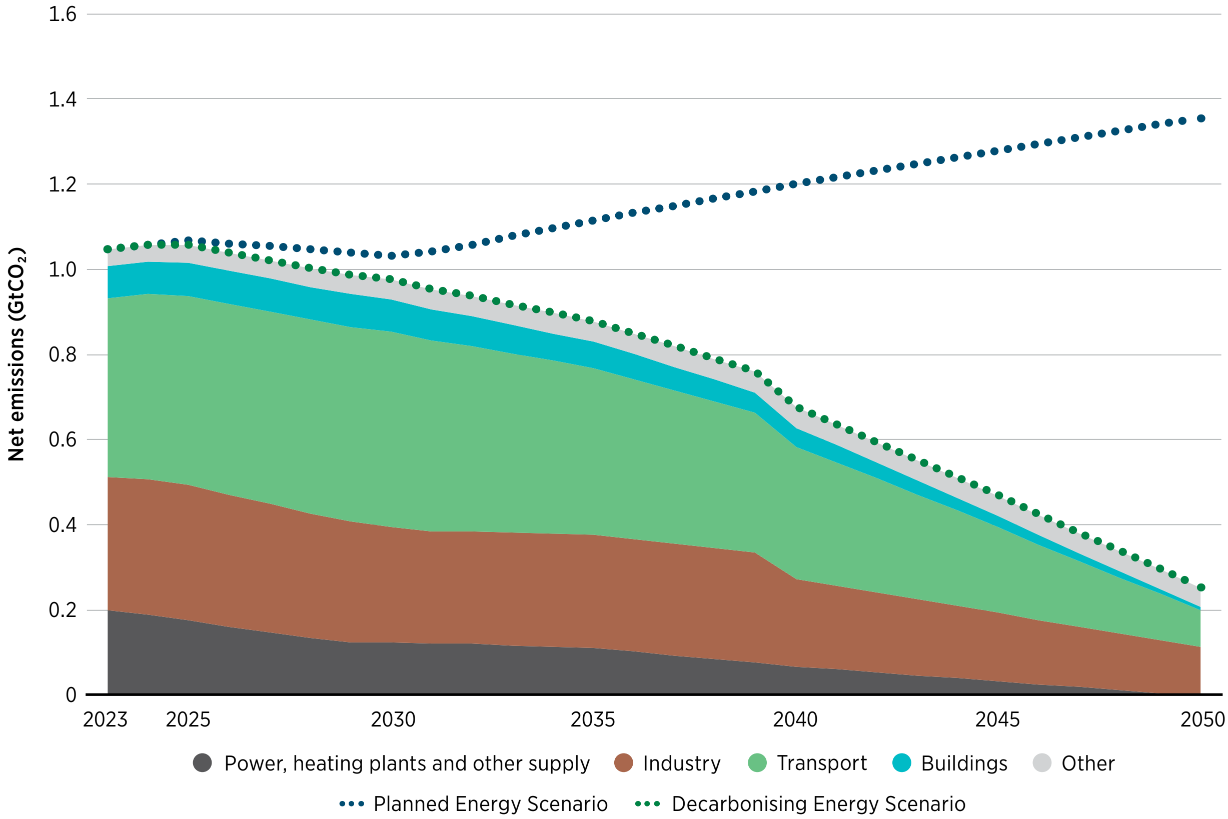



**Notes:** G20 = group of twenty; kWh = kilowatt hour; LCOE = levelised cost of electricity.

Under the PES, for the first few years of the study period, the region's emissions are expected to remain at similar levels (see Figure 1.2). Due to growth in activity among end-use sectors, however, emissions then begin to increase and would be higher than the 2023 base year by 2050. This indicates that additional regional ambition is needed – along with policies, plans, regulations and pledges – to reflect the desired trend of keeping the global rise in temperature to 1.5°C. This chapter highlights these gaps and presents an overview of the roadmaps taking the region towards a feasible decarbonisation of its energy sector by 2050.

In contrast, therefore, under the DES, all the region's sectors contribute to a downward trajectory in emissions (see Figure 1.2), with the transport sector and industry as key players. By 2050, a reduction in emissions of over 75% is achieved compared to 2023 level, if the DES is successfully implemented. The DES also sees a downwards trajectory in emissions begin almost immediately.

**Figure 1.2** Net $CO_2$ emissions in South America under the PES and DES, by sector, 2023-2050




**Notes:** $CO_2$ = carbon dioxide; DES = decarbonising energy scenario; $GtCO_2$ = gigatonnes of carbon dioxide; Other = includes other consumption in energy balances (*e.g.* agriculture, mining, fishing); PES = planned energy scenario.

Several South American countries have been taking steps in the direction of emissions reduction. Yet the level of ambition in the nationally determined contributions (NDCs) submitted so far is insufficient. The majority of NDCs are also not aligned with regional energy plans, indicating a limited chance for their realisation (IRENA, 2023a).

In addition, as of August 2025, only Brazil, Ecuador and Uruguay had submitted an updated NDC 3.0. Within the region, the Plurinational State of Bolivia, the Co-operative Republic of Guyana and the Republic of Suriname have renewable energy targets, while Ecuador and the Bolivarian Republic of Venezuela have energy efficiency targets in their NDCs (Table 1.1).[4]

[4] *This table maps renewable energy and energy efficiency targets reflected in NDCs of South American countries and does not account for targets in other initiatives or plans. French Guiana, as a department of the French Republic, is covered under France's NDC submission, which is part of the EU's joint NDC.*

**Table 1.1** NDC status for renewable energy and energy efficiency in South America

| COUNTRY | NDC VERSION | RENEWABLE ENERGY | ENERGY EFFICIENCY |
|---|---|---|---|
| The Argentine Republic | 2 | Mentioned, no target | Mentioned, no target |
| The Plurinational State of Bolivia | 2 | 13.25% of installed capacity by 2030, conditional on international support | Mentioned, no target |
| Brazil | 3 | Mentioned, no target | Mentioned, no target |
| Chile | 2 | Mentioned, no target | Mentioned, no target |
| Colombia | 2 | Mentioned, no target | Mentioned in context of electricity, hydrocarbons, and mining. No target |
| Ecuador | 3 | Mentioned, no target | The following sector targets given for reduction by 2035 (million barrels of oil equivalent [MBOE]):<br>Residential, commercial, and public sectors: Reduce by at least 88.8 MBOE.<br>Industrial sector: Reduce by at least 29.9 MBOE.<br>Transport sector: Achieve a cumulative reduction of 339.6 MBOE.<br>Energy sector (production, transformation, transmission and distribution): Reduce by 83.7 MBOE.<br>Galápagos Islands: Fossil fuel consumption reduced to 0.36 MBOE and sustainable energy increased to 0.5 MBOE. |
| Guyana | 2 | 100% renewable power supply by 2025, conditional on international support | Mentioned, no target |
| Paraguay | 2 | No direct targets in NDC, but mentions National Energy Policy 2040 targets.<br>Renewable infrastructure: Solar power plants (2 000 megawatts [MW]), small hydroelectric plants (500 MW), battery storage systems (5 520 GWh/year), operational by 2040 | Mentioned, no target |
| Peru | 2 | No target | No target |
| Suriname | 2 | Renewables take 35% share of electricity generation by 2030, conditional on international support | Mentioned, no target |
| Uruguay | 3 | No target | No target |

| COUNTRY | NDC VERSION | RENEWABLE ENERGY | ENERGY EFFICIENCY |
|---|---|---|---|
| **The Bolivarian Republic of Venezuela** | 2 | 50 MW installed capacity of wind power by 2030 | The following demand reduction measures out to 2030: An incandescent light bulb ban, leading to 867.66 GWh in reduced power demand<br>TV labelling, leading to 30.61 GWh in reduced demand<br>Cooking equipment labelling, leading to 322.76 GWh in reduced demand<br>Electric water heaters, reducing demand by 50.16 GWh<br>Laundry drier labelling, reducing demand by 43.74 GWh<br>Efficient buildings, reducing demand by 1 229 GWh |

**Note:** As a department of the French Republic, French Guiana is covered under France's NDC submission, which is part of the EU's joint NDC.

## 1.2 OVERVIEW OF THE ENERGY TRANSITION PATHWAYS

### 1.2.1 South America's regional key performance indexes

Following IRENA's WETO 2024 framework, six key performance indexes (KPIs) for the South American region have been set (IRENA, 2024a). These aim to support policy makers in identifying priority actions, tracking progress and guiding strategic actions that can contribute to the decarbonisation of the region.

The KPIs for the South America region are presented in Table 1.2. This table also compares the DES with the PES for 2030, 2040 and 2050.

These KPIs highlight the following:

- Compared with the 2023 base year, electricity generation in South America increases by 2.1 times under the PES by 2050, while under the DES, it almost doubles that growth. This highlights the more ambitious electrification targets in the DES across end-use sectors, and the additional need for green hydrogen production, given the region's aspirations to become a hydrogen export hub.
- South America has the potential resources and the cost competitiveness to enable it to generate more than 90% of its electricity from renewables by 2050, under the PES. Under the DES, that figure rises to almost 100%. This is supported by the countries' alternative energy resources (*i.e.* optimised levels of natural gas) and storage solutions that ensure grid reliability.
- Under the PES, the total installed capacity of renewables (*i.e.* bioenergy, solar, wind, hydro, ocean and others) needs to expand by 2.6-times by 2050, compared to the 2024 latest statistic of 312 GW. Under the DES, this capacity increases five-times (to 1 687 GW in total). The exponential growth under the DES implies annual additions of around 55 GW during the study period, with this including an increase in solar PV of 33 GW/year and wind of 15 GW/year.

- Under the DES, direct uses of renewables increase to one-third of total final energy consumption (TFEC) by 2050. This is mainly accounted for by the intensified use of sustainable bioenergy in the transport sector and industrial processes. Overall consumption of sustainable bioenergy more than doubles under the DES by 2050 (compared to 2023 level). Solar thermal complements this contribution, mostly in thermal processes in buildings and other industries.
- As a result of the high renewable share in both direct and indirect uses, the overall share of renewables in the demand-side energy mix rises to more than 80% by 2050 under the DES, matching the global results in IRENA WETO 2024 analysis (IRENA, 2024a).
- Energy efficiency plays a central role in the DES, supported by the retrofitting of production plants; the deployment of best available technologies (BATs); the implementation of efficiency standards and labelling; and the electrification of equipment. These measures would allow a continuous decrease of around 1% per year in the region's energy intensity (calculated as total primary energy supply per USD of GDP), over the 2023-2050 period. This would contribute to significant $CO_2$ emission reductions.
- Under the DES, electrification expands across all end-use sectors, allowing electricity to account for almost half of total final energy consumption by 2050. In the long-term, transport is the major contributor to this trend supported by a hybrid strategy for sector decarbonisation combining sustainable biofuels with electrification, reflecting the resources and current context of the region.
- Across South America, the production of clean hydrogen is already contained in many national long-term plans, for end-use sectors and exports. The DES leads to annual production of around 22 Mt of clean hydrogen by 2050. More than 75% of this is dedicated to exports, given current ongoing strategies in the region, under which many South American countries have expressed an interest in exporting hydrogen and its derivatives. Reaching this trade ambition, in parallel with integration into domestic demand, would translate into approximately 1 300 TWh of electricity demand, representing over 25% of the region's total electricity generation by 2050.
- In the long term, the deployment of CCS and BECCS technologies is necessary to tackle outstanding emissions. These are mainly due to some fossil fuel-based manufacturing industries still being in operation in 2050. Under the DES, CCS and BECCS deployment is implemented in both end-use sectors and electricity generation. This allows over 1 $GtCO_2$ to be captured, cumulatively, over the 2040-2050 period.

**Table 1.2** KPIs for achieving the PES and DES, 2023-2050

| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **KPI.01 RENEWABLES (POWER)** | | | | | | | |
| Renewable energy electricity generation (TWh/yr) | 982 | 1 318 | 1 854 | 2 464 | 1 524 | 3 057 | 4 967 |
| Renewable energy share in electricity generation (%) | 79% | 89% | 92% | 93% | 91% | 97% | 98% |
| Renewable energy installed capacity (GW) | 290 | 382 | 563 | 822 | 428 | 907 | 1 687 |
| Renewable energy share in installed capacity (%) | 71% | 76% | 76% | 78% | 77% | 80% | 86% |

## KPI.**02** RENEWABLES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total primary energy supply (TPES) (EJ) | 24 | 28 | 33 | 39 | 28 | 32 | 37 |
| Renewable energy share in TPES (%) | 36% | 43% | 46% | 48% | 52% | 66% | 85% |
| Total final energy consumption (TFEC) (EJ) | 19 | 22 | 27 | 32 | 21 | 23 | 24 |
| Renewable energy share in final consumption (%) - direct + indirect[1] | 32% | 38% | 42% | 45% | 40% | 59% | 81% |
| Renewable energy share in final consumption (%) - direct only | 20% | 22% | 22% | 22% | 23% | 28% | 34% |
| Modern use of bioenergy (EJ) | 3.7 | 4.5 | 6.0 | 7.3 | 4.9 | 7.2 | 9.2 |
| Biofuels production volume (billion L)[2] | 40 | 61 | 88 | 111 | 63 | 87 | 97 |

## KPI.**03** ENERGY INTENSITY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Energy intensity improvement rate (%)[3] | 0.8% | 0.7% | 0.2% | 0.5% | 0.7% | 0.6% | 1.0% |

## KPI.**04** ELECTRIFICATION IN END-USE SECTORS (DIRECT)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Electrification rate in total final energy consumption (%) | 20% | 21% | 23% | 25% | 22% | 33% | 48% |
| Electricity consumption (TWh) | 1 049 | 1 252 | 1 704 | 2 229 | 1 274 | 2 077 | 3 105 |

## KPI.**05** CLEAN HYDROGEN AND DERIVATIVES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Production of clean hydrogen (MtH$_2$eq)[4] | 0[5] | 0.002 | 0.2 | 0.9 | 2.8 | 11 | 22 |

## KPI.**06** CCS, BECCS AND OTHERS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Energy and process $CO_2$ captured from CCS, BECCS and other removal measures (Mt$CO_2$) | 0.0 | 0.0 | 1.3 | 5.0 | 0.0 | 65 | 127 |

Notes:

1 *Indirect uses refer to use of renewables for production of secondary carriers, e.g. electricity, green hydrogen*

2 *Biofuels refer to biodiesel and bioethanol*

3 *Comparison of energy intensity values with moving window of 10 years. Value of 2023 calculated with IEA statistics comparing 2020 vs 2010. Value of column "2030" refers to a moving window of 10 years based on 2023 (i.e. 2033 vs 2023)*

4 *Clean hydrogen refers to blue and green hydrogen*

5 *Value of 2023 corresponds to grey hydrogen*

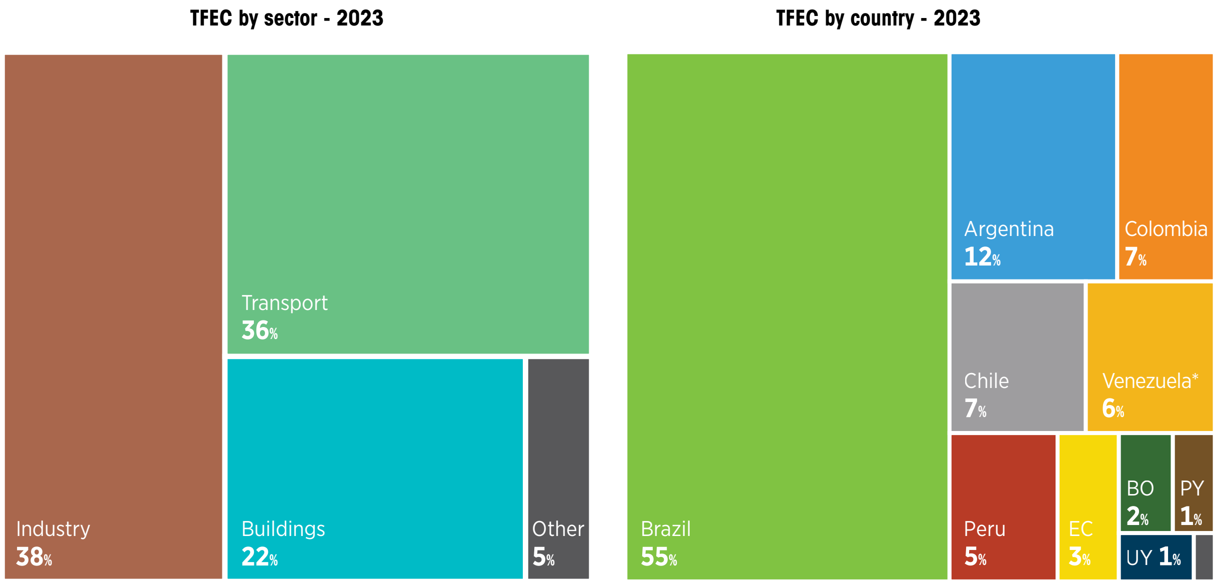
**KPI 01** refers to the use of renewables in electricity generation, **KPI 02** presents the direct use of renewables in total final energy consumption ([TFEC] which includes energy and non-energy uses) and the quantity of sustainable bioenergy used. **KPI 03** is based on energy intensity calculated as total primary energy supply (TPES) divided by gross domestic product (GDP), which serves as an input to compute the compound rate at which energy intensity declines annually. This is a measure of the efficiency gains in energy use, necessary to reduce energy demand and emissions. **KPI 04** corresponds to the level of electrification of end-use sectors. The production of clean hydrogen and its derivative fuels are monitored through **KPI 05**. Finally, the framework tracks the amount of $CO_2$ captured and removed by several measures with **KPI 06**.

BECCS = bioenergy carbon capture and storage; CCS = carbon capture and storage; $CO_2$ = carbon dioxide; EJ = exajoule; GW = gigawatt; H2eq = hydrogen equivalent; L = litres; Mt = million tonnes; TWh/yr = terawatt hour per year.

### 1.2.2 Total final energy consumption: An end-use breakthrough

South America's total final energy consumption (TFEC) was around 19 EJ in 2023, with the industry sector the largest consumer, accounting for 38% of the total. This was followed by the transport sector (see Figure 1.3). When TFEC is broken down by country, Brazil was the highest energy consumer in 2023, accounting for more than half of the regional total. Argentina, Chile and Colombia together covered around a quarter of the total (see the right panel of Figure 1.3).

**Figure 1.3** South America's TFEC by end-use sector (left) and by country (right), 2023



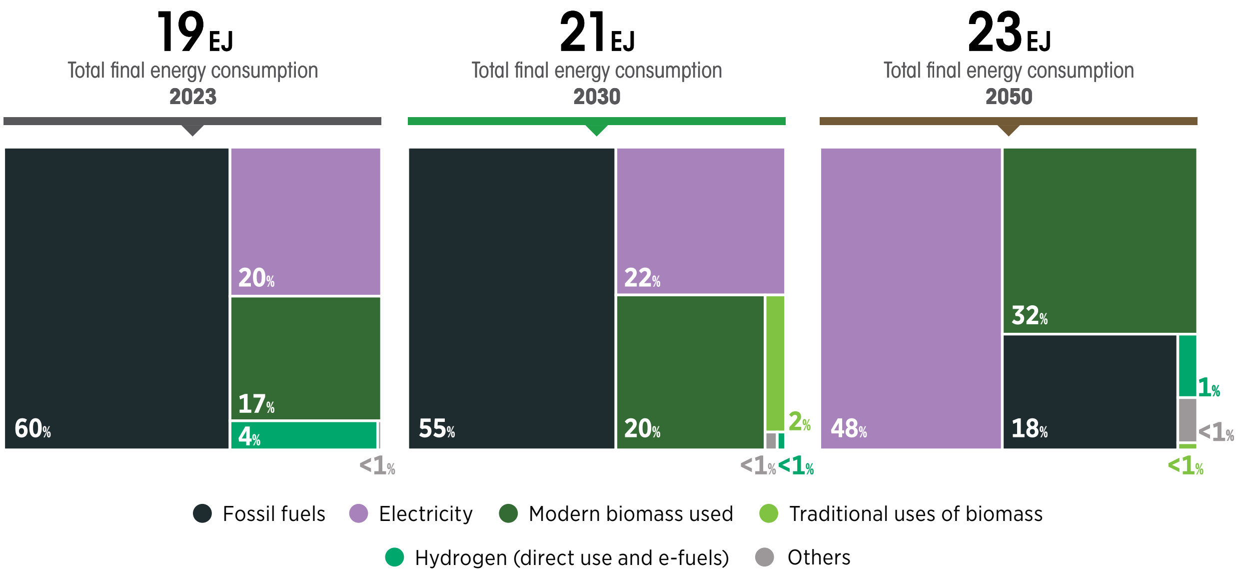

**Notes:** Values refer to energy uses only (does not include non-energy). TFEC by country remaining grey block corresponds to French Guiana, Guyana and Suriname (share <1%). ; BO = The Plurinational State of Bolivia; PY = Paraguay; TFEC = total final energy consumption; UY = Uruguay; * The Bolivarian Republic of Venezuela.

In terms of the energy mix, in 2023, TFEC was dominated by fossil fuels, with these accounting for 60% of the total. Electricity and renewables (mainly sustainable bioenergy) accounted for 20% and 20%, respectively.

Taking into account the context and potential of the region, the DES pathway includes a portfolio of decarbonisation measures that would lead to a re-structuring of the regional energy mix by 2050. This new mix gives a higher share to electricity – 48% of TFEC – and to sustainable bioenergy, with 32% of TFEC (see Figure 1.4). Clean hydrogen also features in the DES energy mix, contributing 1%. This is mostly in the industrial sector and as a blending agent in the natural gas grid, following plans contained in country strategies. In contrast, by 2050 the usage of fossil fuels declines around 65% from its 2023 level under the DES, while traditional biomass would be almost completely phased out.

This decrease in fossil fuels brings several benefits, not only in the reduction of $CO_2$ emissions, but also in diminishing long-term import dependency. This is significant, as imports of fossil fuels – crude oil, natural gas and coal – represented around 10% of total energy supply in 2023, according to OLADE (OLADE 2024b). Moreover, the use of sustainable bioenergy instead of traditional biomass in cooking and thermal processes would contribute to a reduction in household pollution, which typically affects women and children the most.

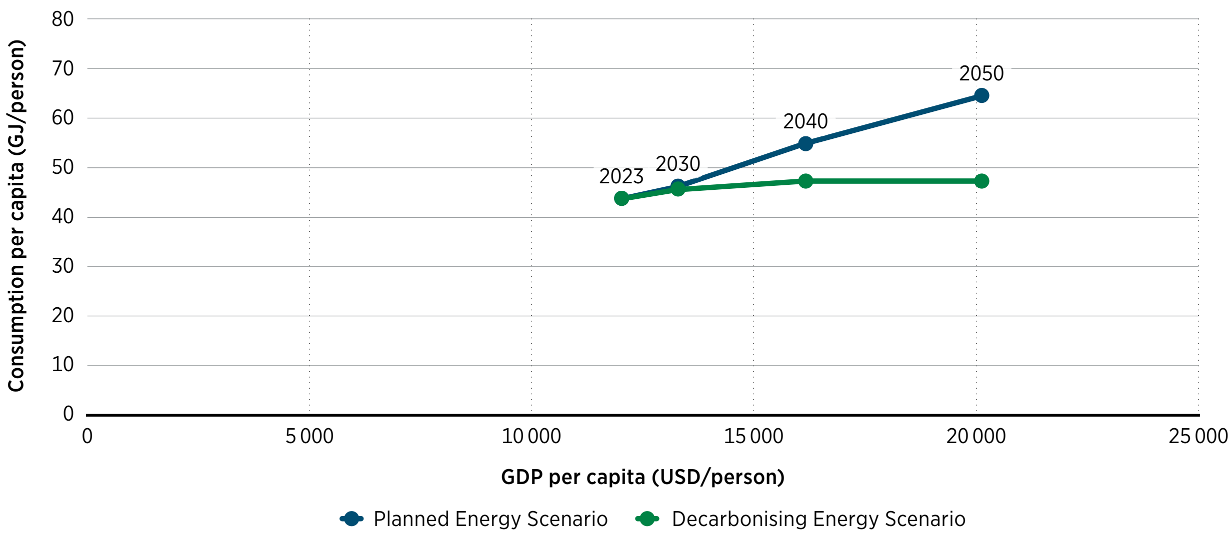
**Figure 1.4** Breakdown of South America's TFEC under the DES, by energy type, 2023, 2030 and 2050




**Notes:** Values refer to energy uses only (does not include non-energy); The category "Other" refers to other renewables (*e.g.* solar thermal); DES = Decarbonising Energy Scenario; EJ = exajoule; TFEC = total final energy consumption.

For both the PES and DES, Figure 1.5 shows the evolution of the region's TFEC per capita over the study period. The cumulative effect of the South American countries' national plans leads to an increase in this energy indicator of over 45% by 2050, compared to the 2023, reaching 44 gigajoules (GJ) per person. The combination of measures implemented under the DES would allow TFEC per capita to remain at a similar level to today throughout the study period, despite the growth in population, industrial manufacturing and regional trade ambitions.

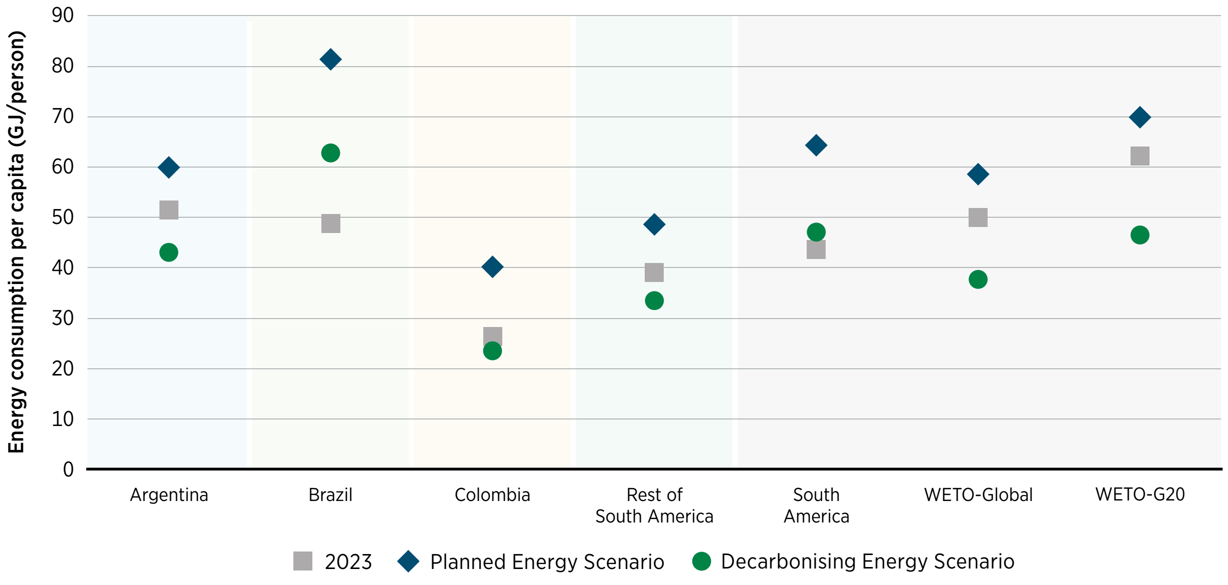
**Figure 1.5** Evolution of TFEC per capita under the PES and DES, 2023-2050




**Notes:** OLADE reports 45 GJ/person for 2010. GDP unit in 2024 USD base; GJ = gigajoule; TFEC = total final energy consumption.

Country and regional comparisons of TFEC per capita are shown in Figure 1.6. In 2023, this statistic ranged between 25 GJ per person and 55 GJ per person, depending on the country/cluster. To put that into a global perspective, in 2023, TFEC per capita in South America was 13% less than the global weighted average and 30% less than G20 levels. By 2050, the PES of South America shows that current national plans would follow the same trend as the aggregate effect of global energy plans, while under the DES pathway (customised for the region), the region would reach same level as G20's 1.5°C perspective (IRENA, 2024a).

**Figure 1.6** TFEC per capita in 2023 and under the PES and DES by 2050 across South America, the world and the G20

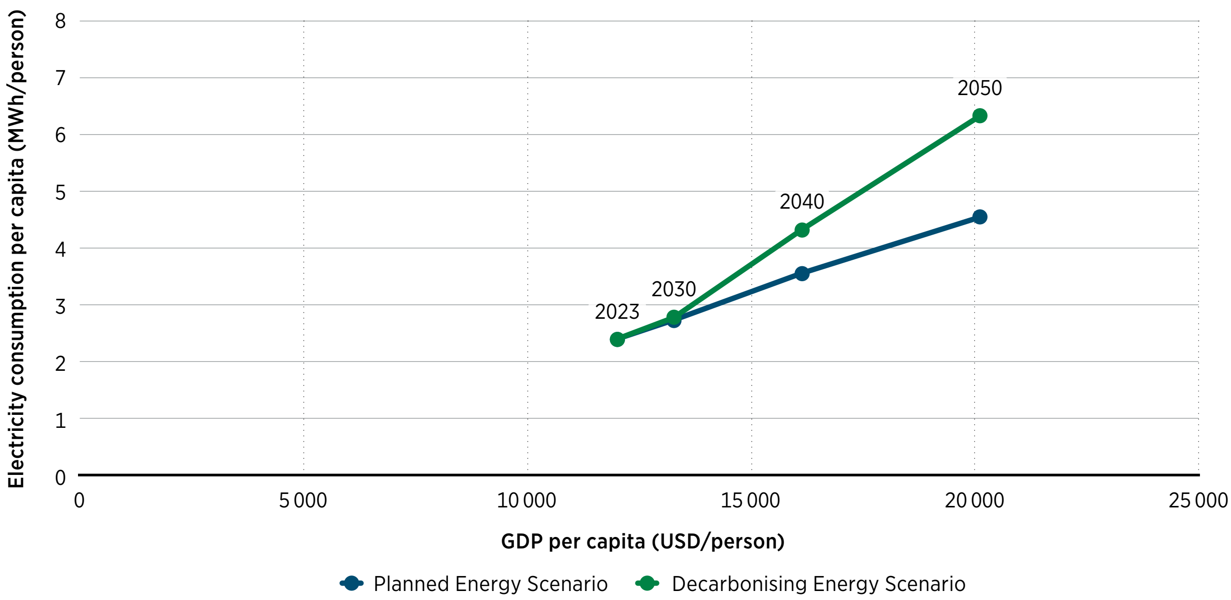



**Notes:** DES = Decarbonising Energy Scenario; GJ = gigajoule; PES = Planned Energy Scenario; TFEC = total final energy consumption; WETO = IRENA World energy transition outlook.

### 1.2.3 Increasing electrification and sustainable fuels in TFEC: Direct uses

The region's annual electricity consumption per capita averaged around 2.4 MWh in 2023. Given each country's planned electrification levels, this value is set to double by 2050. Under the DES, however, this figure would grow 2.7 times the current levels. This would mean a per capita annual weighted average of 6.3 MWh in 2050 (Figure 1.7). This increase indicates some ambitious electrification efforts in the transport sector, as well as increased electricity consumption to cover production of green hydrogen for export.

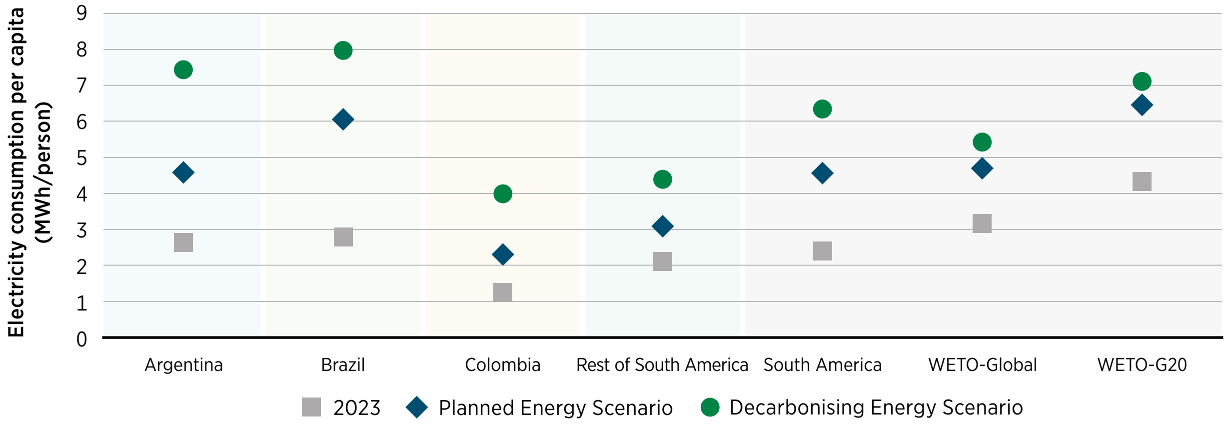
**Figure 1.7** Electricity consumption per capita under the PES and DES, 2023-2050




**Notes:** OLADE reports 2.1 MWh per person for 2010. GDP unit in 2024 USD base; MWh = megawatt hour.

Figure 1.8 shows the electricity consumption per capita of South American clusters and the global and G20 averages in IRENA's WETO 2024 analysis (IRENA, 2024a). In the region, the current levels range between 1 000 kWh per person and 3 000 kWh per person. The South American average in 2023 was almost 25% less than the global average and approximately 45% less than that of the G20. Under the PES, by 2050, South America is set to reach a similar level to the estimated value under the PES for the globe given in IRENA's WETO 2024 analysis (IRENA, 2024a). Under the DES, the region's electricity consumption per capita in 2050 increases to a value higher than the WETO 2024 global level, but lower than the WETO 2024 G20 level.

**Figure 1.8** Electricity consumption per capita in 2023 and under the PES and DES by 2050 across South America, the world and the G20

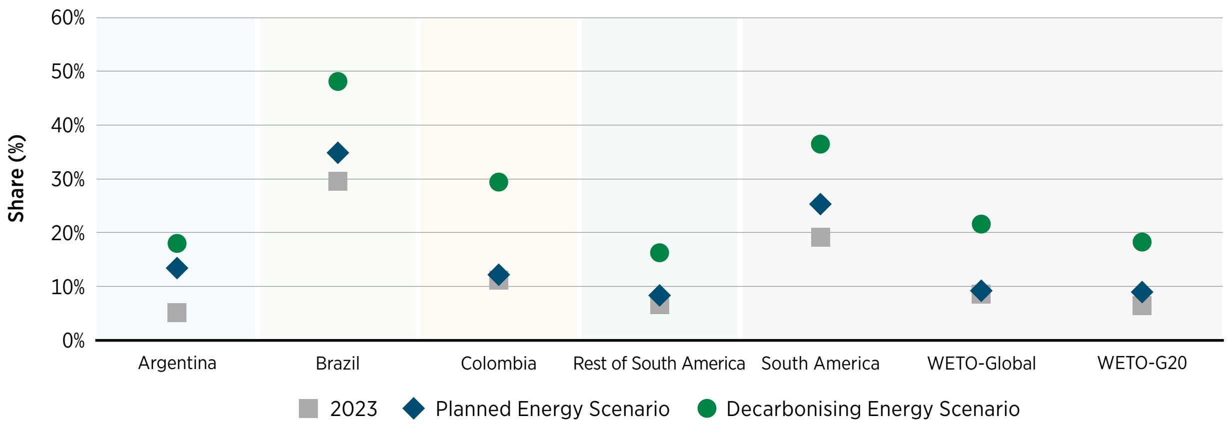



**Notes:** DES = Decarbonising Energy Scenario; MWh = megawatt hour; PES = Planned Energy Scenario; WETO = IRENA World energy transition outlook.

In addition to the levels of electrification, one of the main characteristics of the South American energy transition is the high level of deployment of bioenergy in end-use sectors. These deployments range from sustainable biomass in cooking, thermal and chemical processes, to liquid biofuels used for road, air and maritime transport.

Figure 1.9 shows the share of TPES taken by bioenergy in the region's clusters and compares this with IRENA's WETO 2024 levels for the world and the G20 (IRENA, 2024a). The South American share is higher (even double) than the global and G20 averages. By 2050, more than one-third of the region's TPES could come from bioenergy, if the DES is implemented.

**Figure 1.9** Share of sustainable bioenergy in TPES in 2023 and under the PES and DES by 2050 across South America, the world and the G20

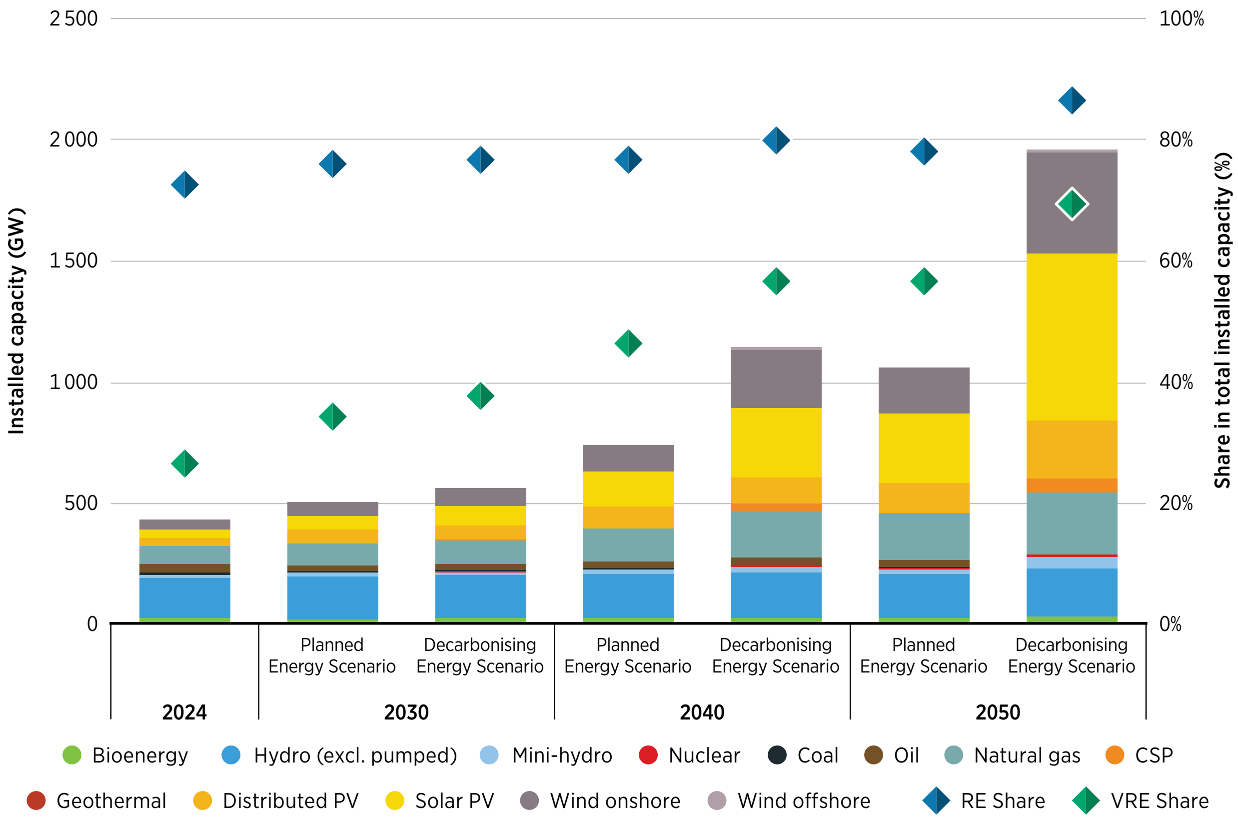



**Notes:** DES = Decarbonising Energy Scenario; G20 = group of twenty; PES = Planned Energy Scenario; TPES = total primary energy supply; WETO = IRENA World energy transition outlook.

### 1.2.4 Roadmap for renewables in power sector capacity

Figure 1.10 presents the evolution of South America's total installed power generation capacity out to 2050 under the PES and the DES. In both scenarios, capacity expands significantly, but the scale and composition of that capacity differ markedly. Under the PES, total capacity grows moderately, with fossil fuels – and natural gas in particular – continuing to play a central role alongside a gradual rise in renewables. In contrast, the DES sees a far more rapid expansion in installed capacity, nearly doubling the PES level by 2050. This growth is driven by a sharp increase in variable renewable energy (VRE) sources, particularly solar and wind, which together account for nearly 70% of total capacity by 2050. Distributed generation and mini-hydro also grow notably, supporting greater decentralisation and resilience. As a result, in the DES the share of renewable energy reaches over 85% of total capacity by 2050, compared to around 78% in the PES. The figure below emphasises the fundamental structural change required under the DES compared to PES. This change is not only in terms of the mix of technologies, but also in the total system scale, as growing demand is met by sustainable sources.

**Figure 1.10** South America's total installed power capacity (GW) and share of renewables in total installed capacity (%) under the PES and DES, 2024-2050



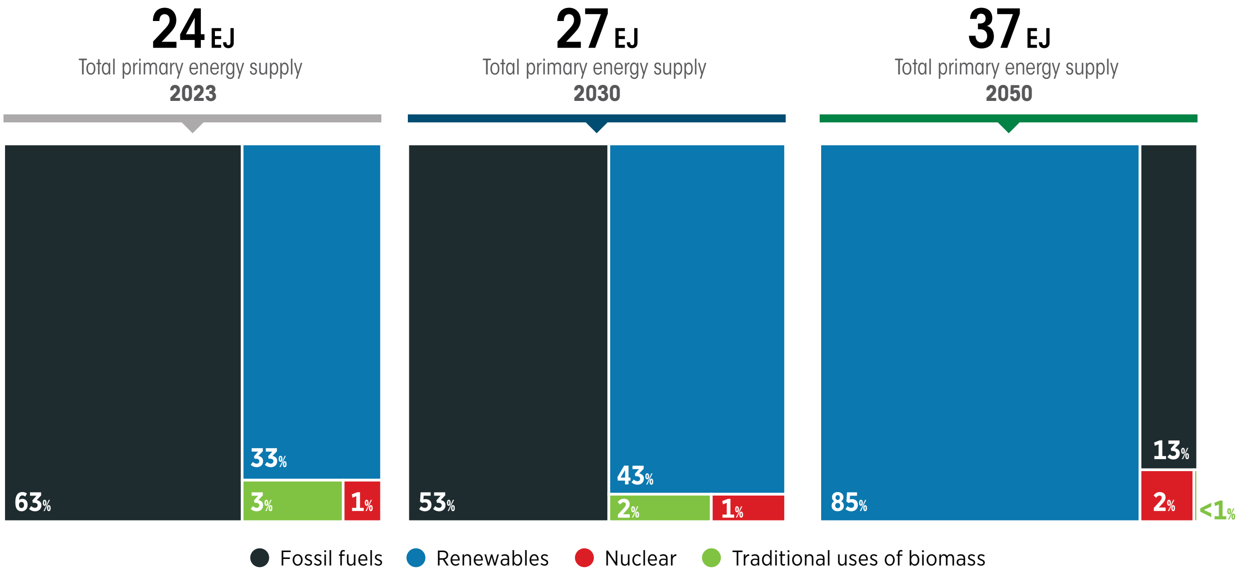

**Notes:** CSP = concentrated solar power; DES = Decarbonising Energy Scenario; GW = gigawatt; PES = Planned Energy Scenario; PV = photovoltaic; RE = renewable energy; VRE = variable renewable energy.

### 1.2.5 Phasing out fossil fuels and improving energy efficiency

In 2023, South America's TPES was around 24 EJ (some 4% of global primary supply). This was dominated by fossil fuels, which accounted for around 63% of the energy mix. Renewables (including sustainable bioenergy) then accounted for around 33%, as depicted in Figure 1.11. Traditional biomass, which is mainly used for cooking, accounted for 3%. Nuclear energy complemented the energy mix, with 1%, all of which went to electricity generation.

The figure 1.11 also shows the evolution of TPES under the DES in both the short- and long-term. Compared to the 2023 base year, by 2030, TPES would increase 10%, with a rise in the share taken by renewables and a decline in that taken by fossil fuels. By 2050, energy levels would reach 37 EJ, representing a growth of over 50% on the 2023 value. This is instead of the more than 60% increase that the current energy plans of the region's countries – the PES – would entail. In terms of the energy mix, renewables would dominate, with an 85% share, while fossil fuels could account for only around 13%. Traditional biomass is almost completely phased out, while nuclear power's contribution would be in similar level as of today. In its calculations, the DES considers only those installations that are current or planned in each specific country's power sector programmes.

**Figure 1.11** South America's TPES breakdown under the DES, by energy source, 2023, 2030 and 2050




**Notes:** Renewables include modern uses of biomass; DES = Decarbonising Energy Scenario; EJ = exajoule; TPES = total primary energy supply.

Several South American countries are significant fossil fuel producers, with this group including Brazil, Colombia, Argentina, Suriname and the Bolivarian Republic of Venezuela. Since 2010, the latter country's oil production has dropped by around 75%, however, while Argentina's conventional sources are declining. Conversely, Brazil's hydrocarbon production has increased by almost 40% since 2010, while Guyana recently began offshore hydrocarbon production.

The South America region holds about 15% of the world's oil and gas resources, according to the IEA. By 2030, oil production in the region will exceed its demand growth, however, raising South America's liquid exports by nearly 2 million barrels per day. Brazil and Guyana alone will contribute over 1 million barrels per day to the world's liquid exports by 2035. New oil and gas-related projects face trade risks, however, if global oil demand declines due to progress on net-zero goals by 2050 (IEA, 2023a).

Natural gas production in the region is also projected to decline slightly by 2030, leading to an initial increase in gas imports. If global goals to reduce flaring and methane emissions are met, gas production will fall more steeply, however, and imports could shrink to 30 billion $m^3$ by 2050. At the same time, Argentina is expected to expand gas production in the years ahead, shifting regional consumption patterns. Indeed, Argentina, Brazil, Colombia and the Bolivarian Republic of Venezuela are set to continue to develop exploitable gas reserves, driven by domestic demand, competitive prices and lower production costs, in the period ahead (IEA, 2023a).

In terms of coal, Chile stands out as the only country in South America that has made a formal commitment to phasing out this fuel source. Since 2019, Chile has been retiring its coal-fired power plants, aiming for a full phase-out by 2040. As of 2024, 11 coal plants – totalling over 1.2 GW of capacity – had been retired, with an additional nine units set to retire or convert to natural gas by 2025. Chile's 2022–2026 Energy Agenda further anchors these actions within a broader framework for a fair and socio-ecological energy transition (Climate Action Tracker, 2024).

Colombia and Ecuador have also taken some important steps in fossil fuels. In Colombia, government officials as of 2025 have pledged to gradually reduce the size of the extractive industry by halting new mining and oil and gas exploration concessions, while enhancing production from existing fields. The government aims to offset fiscal losses by strengthening tourism, agriculture and ownership of renewable energy assets, particularly in former coal-mining regions such as La Guajira and Cesar. Ecuador, meanwhile, made history in 2023 by holding a nationwide referendum in which the majority of citizens voted to halt all oil drilling in the Yasuní National Park. This was a major milestone in the country's fossil fuel phase-out strategy, with existing oil wells in the park scheduled to close by the end of 2029 (Bae *et al.*, 2024; World Bank, 2025).

In addition, Chile, Colombia and Peru have joined the Powering Past Coal Alliance. This is a coalition of 61 national and 52 subnational governments – along with 68 businesses and other organisations – that is working to advance the transition from unabated coal power generation to clean energy. Joining this coalition reinforces these countries' commitment to transitioning away from coal power toward cleaner energy sources (PPCA, n.d.).

Phasing out fossil fuels presents complex trade-offs, however. A full and immediate fossil fuel exit could significantly raise electricity prices, threaten energy security and result in substantial economic costs across the region. Those economic costs could include the loss of up to 100 000 direct and indirect jobs and up to 3% of GDP in fiscal revenues and royalties (Bae *et al.,* 2024; Cabrales and Delgado, n.d.). With regard to electricity prices, energy is a significant part of household expenses in the region, especially for low-income families, who spend 7% to 9% of their budget on electricity (IEA, 2023b). Fossil fuel subsidies have so far supported low power prices and ensured energy affordability for the poor in many South American nations. Removing electricity subsidies could therefore be challenging, since these measures exceed one percentage point of GDP in some countries (IMF, n.d.).

In addition, fossil fuel subsidies in the region are very high, compared to developing countries such as India and China. According to IMF statistics, in 2022, total fossil fuel subsidies in the region accounted for around USD 233 billion.[5] The share of GDP taken by these subsidies ranged from a low of 2% in countries such as Uruguay and Brazil to over 30% in countries such as the Bolivarian Republic of Venezuela, Suriname and the Plurinational State of Bolivia (IMF, n.d.). Subsidies have sizable fiscal consequences, such as higher taxes and borrowing, or lower spending. They can also promote an inefficient allocation of an economy's resources, hindering growth, while also increasing pollution, which in turn contributes to climate change and premature deaths from local air pollution. Rationalising subsidies and using the revenue gain for better-targeted social spending, reductions in inefficient taxes and productive investments can lead to sustainable outcomes. It can also help address energy security concerns related to volatile fossil fuel prices and supplies.

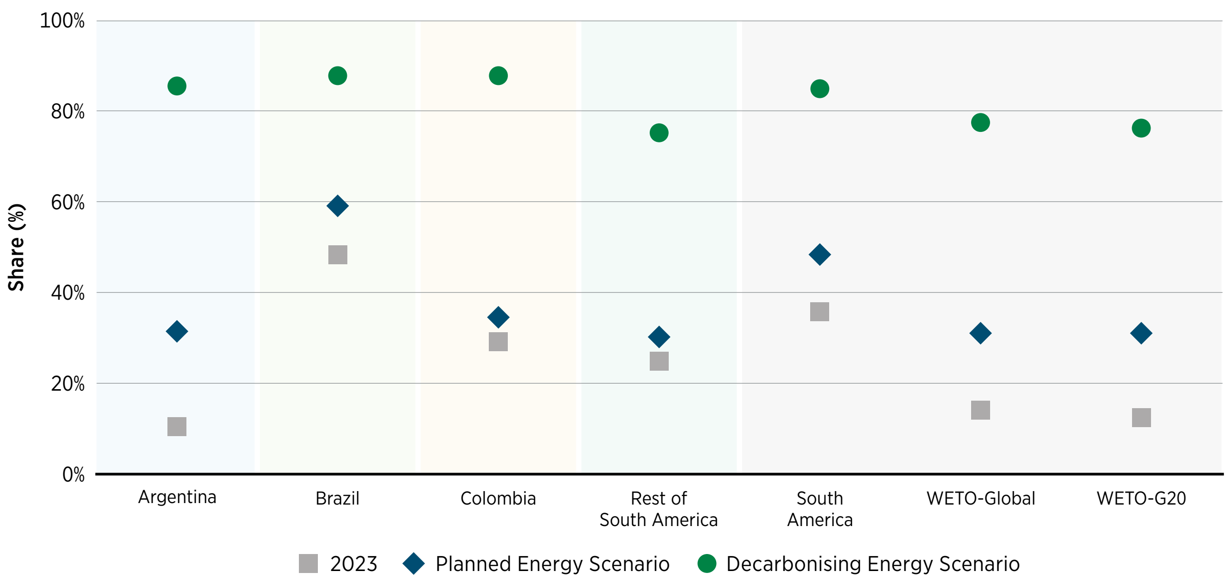
In light of these risks, a more phased reduction in fossil fuel extraction can provide vital financial resources to support a successful energy transition. Adaptation measures to address climate risks also require sustained financing. For instance, a report published in 2024 by the National Bureau of Economic Research indicates that each 1°C increase in global temperature could be linked to a decline of over 10% in global GDP (World Economic Forum, 2024). For the year 2024 alone, estimations of the global cost of extreme weather events range from USD 348 billion (Earth.Org, 2025) to USD 417 billion (Risk and Insurance, 2025).

[5] *All prices and subsidy values are at 2021 constant prices. The IMF measures fossil fuel subsidies as the difference between retail prices and supply costs (explicit subsidies), plus the failure to charge for external costs and apply standard consumption taxes (implicit subsidies). Explicit subsidies include cases where fuel prices are below production or import costs, while implicit subsidies reflect unpriced impacts, such as climate change, health damage and road-use externalities.*

Aligning fossil fuel phase-out strategies with broader fiscal reforms is thus critical. As an example, Brazil's Special Incentives Scheme for the Production of Low-Carbon Hydrogen (Regime Especial de Incentivos para a Produção de Hidrogênio de Baixa Emissão de Carbono [REHIDRO]) demonstrates how redirecting oil sector subsidies (USD 3.3 billion in this case) can bolster new industries like hydrogen (Government of Brazil, 2024a). Fiscal policy tools such as reinvesting fossil fuel profits into clean technologies, reducing fossil fuel subsidies, implementing $CO_2$ pricing when global oil prices fall, and granting value added tax (VAT) exemptions for renewables can all support the transition. Ensuring that these fiscal benefits are distributed equitably is also key to securing public acceptance and building resilience.

Figure 1.12 shows the share of renewables in the TPES by country/cluster and regional weighted-average for the PES and DES in 2050. As observed, the DES would allow renewables to account for 85% of TPES in the region. Moreover, as expected, South America would surpass the global and G20 values, as the scenario fosters the deployment of ambitious levels of the renewable energy available in the region (including sustainable bioenergy).

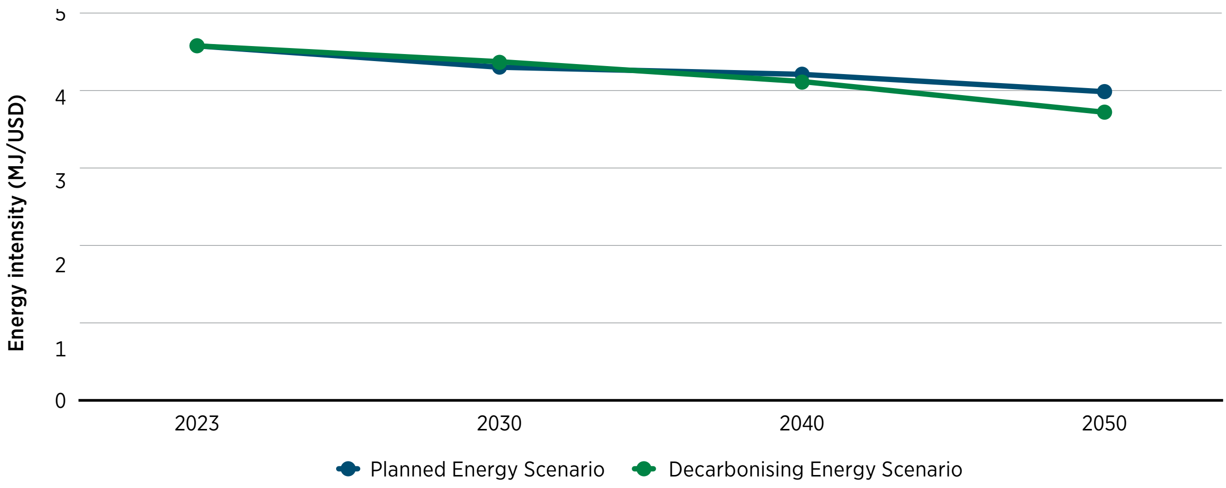
**Figure 1.12** Renewables' share in TPES in 2023 and under the PES and DES by 2050, across South America, the world and the G20




**Notes:** DES = Decarbonising Energy Scenario; PES = Planned Energy Scenario; TPES = total primary energy supply; WETO = IRENA World energy transition outlook.

Figure 1.13 shows the evolution of energy intensity for the South American region, measured in terms of TPES per unit of GDP. The figure also compares the DES and PES over the study period. With respect to the projected growth of the countries' GDP, the cumulative effect of national plans under the PES leads to a decrease in energy intensity of 13% by 2050, compared to the 4.6 MJ per USD of GDP in the base year of 2023. Implementation of the DES, however, would allow a reduction of 19% on the 2023 value, with energy intensity reaching 3.7 MJ per USD of GDP.

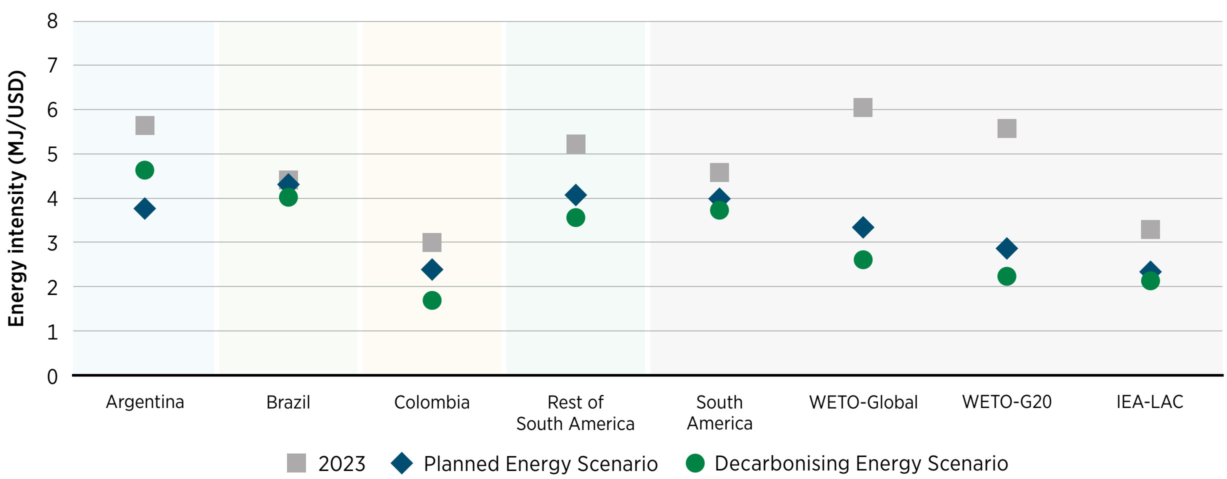
**Figure 1.13** Evolution of South America's energy intensity under the PES and DES, 2023-2050




**Notes:** Slight increase in DES-2030 due to electricity generation needed for clean hydrogen production (trade), on top of final energy consumption; (USD/person); MJ = megajoule.

The South American region's energy intensity is then compared to other groupings in Figure 1.14. The values shown for the region in 2023 range between 3 MJ per USD to 6 MJ per USD. For 2023, the South American region's weighted-average was almost 25% less than the global average. By following national energy plans, the region could decrease its energy intensity by 2050, while the DES would allow a further decline, although South America remains at a higher level compared to that of the world and G20 countries in IRENA's WETO 2024 analysis (IRENA, 2024a).

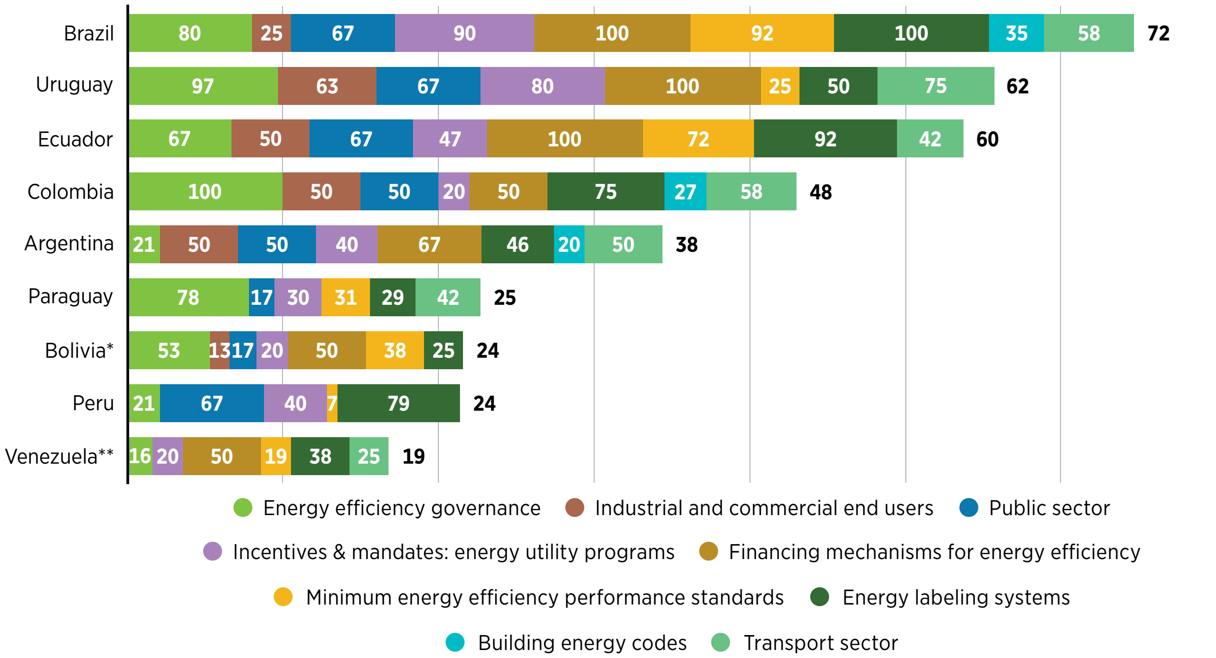
**Figure 1.14** Energy intensity in 2023 and under the PES and DES by 2050 across South America, the World and the G20




**Notes:** IEA-LAC = IEA Latin America and the Caribbean figures. These values come from the IEA-WEO for Latin America and the Caribbean. In this, the "PES" value corresponds to the IEA-LAC STEPS scenario, while the "DES" value corresponds to the IEA-LAC APS scenario (IEA, 2023c); DES = Decarbonising Energy Scenario; MJ = megajoule; PES = Planned Energy Scenario; WETO = IRENA World energy transition outlook.

Meanwhile, in almost every country in South America energy efficiency policies are currently in force in buildings, industry and transport. Labelling schemes, responsible consumption campaigns, investment incentives, renewable energy promotion and efficient buildings have recently been driving building and industrial sector policies in the region, as illustrated in Figure 1.15.

**Figure 1.15** Energy efficiency index scores across South America




**Source:** (ESMAP, n.d.)

**Notes:** The energy efficiency score is based on the nine indicators in the key. Indicators in each pillar are scored between zero and 100 and are weighted equally in order to obtain an overall score for each pillar; * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela.

Over the past decade, the region has made substantial progress in energy efficiency, with its score improving by around 80%.[6] Among the South American countries, Colombia stands out as the most advanced in energy efficiency governance, thanks to its policies and programmes. Key initiatives in that country include the Sustainable Energy and Energy Efficiency Programme in the Caribbean (*Programa de Eficiencia Energética Caribe Energía Sostenible*). This promotes the replacement of cooling, lighting and air conditioning equipment, architectural retrofitting, and small-scale renewable generation for low-income residential and public users. In non-interconnected areas of Colombia, such as San Andres, Providencia and Santa Catalina, the country has piloted efficient demand management programmes. Colombia's legal foundation for energy efficiency was also established early with Law 697 (2001). This declares that the rational and efficient use of energy is a matter of public and national interest. The law also created the Programme for the Rational and Efficient Use of Energy (*Programa de Uso Racional y Eficiente de la Energía* [PROURE]). This was operationalised through the 2017-2022 Action Plan for PROURE (*Plan de Acción Indicativo del PROURE* [PAI PROURE]). Additional regulatory instruments, such as the Technical Labelling Regulation (*Reglamento Técnico de Etiquetado*) made energy efficiency labels mandatory for appliances such as refrigerators, air conditioners, motors, lighting, and washing machines. Vehicle energy labelling was also introduced under the 2018-2022 National Development Plan (the "Pact for Colombia, Pact for Equity"). Financial incentives further strengthen the framework. VAT exemptions apply to high-efficiency appliances, while energy efficiency investments in the industrial sector benefit from significant tax breaks through Law 2099 (2021), with deductions of up to 50% over 15 years for qualifying investments.

[6] *This is according to the ESMAP Regulatory Indicators for Sustainable Energy (RISE) score used in the figure above. This gives a snapshot of a country's policies and regulations in the energy sector.*

Other countries in the region have also made strides forward in energy efficiency. Brazil, for example, mandates that electricity distributors allocate part of their revenues to energy efficiency and R&D through Law No. 9 991 (2000), later updated by Law No. 15 103. Elsewhere, Chile introduced Law 21.305 (2021), which aims to reduce TFEC by 10% by 2030 and 35% by 2050 via a series of sector-specific efficiency goals. Ecuador also adopted its Organic Law of Energy Efficiency in 2019, establishing a national fund and financial mechanisms for project execution.

Although energy efficiency policies are already in place in most South American countries, lack of funding for these initiatives may still be a barrier to further gains. To go further, countries could:

- Provide tax incentives, low-interest loans, or subsidies to promote energy-efficient technologies in households, industry and transport.
- Promote energy service companies to support private sector investment.
- Mandate energy efficiency upgrades in public buildings and fleets.
- Adopt public procurement policies that drive market demand for efficient technologies.
- Develop regional partnerships to harmonise standards and share best practices (*e.g.* regional hubs for energy efficiency and material efficiency).
- Support regional energy efficiency initiatives through organisations such as OLADE.

## 1.3 NON-ENERGY INFRASTRUCTURE AND OTHER REGIONAL ENERGY TRANSITION ENABLERS

### 1.3.1 Regional energy planning and co-operation on regulation

The South American region is also home to a number of initiatives in bilateral co-operation aimed at advancing the energy transition.

In 2019, Argentina and Brazil signed a memorandum of understanding that enables the use of local currencies in energy transactions. This reduces reliance on foreign currency reserves and secures fuel supplies during periods of peak demand. Similarly, in early 2025, Uruguay and Brazil agreed on an agenda for co-operation in strengthening cross-border energy integration. This includes more electricity exchanges, the joint development of renewable energy and hydrogen and the creation of EV charging corridors to support sustainable transport.

On a regional level, there are several intergovernmental, financial, trade and energy co-operation institutions. These are now working on regional power integration and the advancement of opportunities stemming from the region's energy sources and emerging industries. These frameworks and initiatives for regional co-operation have a significant bearing on the positioning and leveraging of the region's resource endowment.

At the same time, the South American region is a key geopolitical partner for many countries and regions elsewhere. This will continue to be so during the energy transition because of South America's rich natural resources, agriculture exports, water availability and abundant land. The region also has a key strategic location with access to both the Pacific and Atlantic Oceans. South America also maintains longstanding ties with Europe through agreements such as the EU-MERCOSUR trade deal. At the same time, several South American countries are integrated with China's global infrastructure strategy via the Belt and Road Initiative.

The region also continues to co-operate closely with the United States through energy and climate diplomacy, investment channels and bilateral agreements. South America is also a participant in emerging geopolitical groupings such as BRICS,[7] in which Brazil plays a leading role.

This positioning gives South America not only access to multiple markets, but also influence in shaping the global energy transition. As global demand rises for green hydrogen and critical minerals, for example, the region is well placed to become a preferred supplier, provided it can align policies, infrastructure and investment incentives. To fully capitalise on this geopolitical endowment, regional institutions must work more closely together to define shared priorities, mobilise investment and create synergies across borders. Stronger co-ordination can also amplify the spill-over effects of the energy transition by supporting local industries, building resilient supply chains and generating jobs throughout the region.

### 1.3.2 Commerce and complementarity in the green supply chain: Logistics and competitiveness

Regional commerce is expanding among the countries covered in this study. This is being driven by greater regional integration, the development of new trade corridors and increased investment in infrastructure. These efforts are contributing to a reduced reliance on extra-regional markets, while also creating more efficient flows of goods and services within the region.

A flagship project in the pipeline is the Atlantic–Pacific railway, a strategic corridor between Brazil, the Plurinational State of Bolivia and Peru. This would greatly reduce transport time and costs between the oceans, as well as provide a direct trade route to Asian markets. This project has the potential to transform regional logistics by modernising ports and border facilities, enhancing cross-border connectivity.

Such integration is critical in advancing the region's energy transition. Spread across the region, South America holds abundant resources that are essential to a range of renewable energy technologies. Argentina, the Plurinational State of Bolivia and Chile have lithium resources; Chile and Peru have copper; Brazil has rare earths; and the Bolivarian Republic of Venezuela and Guyana have hydrocarbons. Improved and modernised trade infrastructure will help reduce supply chain bottlenecks, support regional processing and manufacturing and contribute to lowering the costs of clean energy infrastructure. The natural and industrial specificities of each country – mineral wealth in the Andes, industrial capacity in Brazil and logistics hubs in Uruguay, for example – can contribute to a shared regional competitive advantage.

Nevertheless, the region currently suffers from a low level of goods and passenger mobility between and within its constituent countries. While roads are the predominant means of travel, their quality and the cost of using them are issues. In many areas, efficient means of transport for goods and passengers, such as railways and waterways, are still lacking. This increases the cost of logistics in the region in comparison with other countries. According to an ECLAC bulletin from 2024, the World Bank's Logistics Performance Index (LPI)[8] for Latin America and the Caribbean averaged 2.6 in 2023, while the global LPI was 2.9 and the world best score was 4.3 – obtained by Singapore (ECLAC, 2024).

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[7] *As of October 2025, the BRICS member states were: Brazil, the Russian Federation, India, China, South Africa, Egypt, Ethiopia, Indonesia, the Islamic Republic of Iran, Saudi Arabia and the UAE.*

[8] *The World Bank's LPI covers six components: 1) the efficiency of customs and border management clearance; 2) the quality of trade and transport infrastructure; 3) the competence and quality of logistics services; 4) the ability to track and trace consignments; 5) the timeliness of shipments; and 6) the ease of arranging competitively priced international shipments. The 2023 LPI enables comparisons to be made among 139 countries (World Bank, 2023). Each country receives a score on a scale from 1 (very low) to 5 (very high), with higher scores indicating a better logistics performance.*

Achieving IRENA's decarbonisation pathway for South America will therefore need co-ordinated actions in a number of different sectors. It will mean harmonising trade and transport regulations, investing in cross-border infrastructure, enhancing digital customs and logistics systems, and aligning technical standards for clean energy components. Public-private partnerships and mechanisms for regional co-operation will be key to financing and implementing these transformations.

### 1.3.3 Regional platforms for finance

Perhaps South America's biggest challenge in the energy transition is its limited financing support. Credit ratings for the region's countries that are relatively low have resulted in high interest rates and a lack of risk-sharing mechanisms. Except for Chile, all the regional countries covered in this report have average ratings below the A-grade ratings band, as illustrated in the table below.

**Table 1.3** Sovereign ratings of selected countries in South America, 2025

| COUNTRY | MOODY'S | S&P | FITCH | RISK CATEGORY |
|---|---|---|---|---|
| Argentina | Caa3 | CCC | C | Substantial Risk / Extremely Speculative |
| Plurinational State of Bolivia | Ca | CCC+ | B- | Substantial Risk / Highly Speculative |
| Brazil | Ba1 | BB | BB- | Non-investment grade / Speculative |
| Chile | A2 | A | A- | Upper medium grade |
| Colombia | Baa2 | BB+ | BB+ | Lower medium grade / Non-investment grade |
| Ecuador | Caa3 | B- | B- | Substantial Risk / Highly Speculative |
| Peru | Baa1 | BBB- | BBB | Lower medium grade |
| Paraguay | Baa3 | BB+ | BB+ | Lower medium grade / Non-investment grade |
| Suriname | Caa1 | CCC+ | RD | Substantial Risk |
| Uruguay | Baa1 | BBB+ | BBB- | Lower medium grade |
| Bolivarian Republic of Venezuela | C | B- | WD | Extremely Speculative |

**Source:** (CountryEconomy, n.d.).

Tax policies, such as those in Colombia, are a powerful mechanism to incentivise the achievement of decarbonisation. While governments often lack the resources to offer credit benefits, it may be prudent to consider tax credits or VAT exemptions for specific applications in emerging markets. Other possible measures include accelerated depreciation and reduced tax fees.

The lack of sufficient financing is closely linked to the broader investment climate. This includes factors such as regulatory clarity and the reliability of legal frameworks within a country, both of which help reduce perceived risk. Gaps or uncertainties in these areas result in financing constraints, while altogether, these factors ultimately limit the flow of capital.

Governments and the private sector must therefore work together, using innovative financing solutions, such as blended finance and green bonds, to support the energy transition in emerging markets and developing economies. Public sector involvement is crucial in expanding funding sources and reducing investment risks, while aligning financial mechanisms with long-term planning and environmental goals will foster success. Brazil's achievement in expanding renewable energy investments and strengthening the supply chain is evidence of the efficacy of an integrated approach combining sector planning and financial expertise through key institutions. In Brazil, these institutions include organisations such as the Energy Research Office, the Ministry of Mines and Energy and BNDES (IRENA and BNDES, 2024).

The creation of a regional investment platform focused on supporting finance for energy transition projects could lower debt costs. It could also help secure the benefits of portfolio optimisation, increase the level of technical expertise for project finance and structuring, and improve risk allocation between stakeholders. Through such a platform as the Brazilian Climate and Ecological Transformation Investment Platform (Plataforma Brasil de Investimentos Climáticos e para a Transformação Ecológica [BIP]),[9] regional governments and the private sector could mobilise concessional capital, engage export credit agencies, and partner with multilateral development banks within a blended finance structure. This approach could help scale up funding mechanisms, such as green bonds and targeted grants – particularly for industrial electrification projects with narrow project margins.

### 1.3.4 Critical minerals for the South American energy transition

Many countries in South America are major producers of critical minerals (Figure 1.16). Chile is the world's largest copper producer and also produces around 30% of the global lithium supply. Brazil is a major bauxite and graphite exporter, while Peru and other regional countries play key roles in the supply of other critical minerals, such as nickel and silver. The region also has substantial underexploited reserves, such as lithium in the Plurinational State of Bolivia and rare earths in Brazil (IEA, 2023c).

The region's strong resource base gives it the opportunity to move further along the supply chain to mineral refining and processing. It also gives it the ability to expand into the manufacturing of equipment and other key areas of the supply chain, capturing more value, creating jobs and reducing imports. Major economies such as the EU have shown increasing interest in the region's rich reserves, as evidenced by recent strategic trade agreements between Brussels and Chile and Argentina (Arato, 2025).

To date, South America has not been able to reach its full potential when it comes to creating local value at the higher end of the critical minerals value chain. Brazil, for example, currently has the second largest rare earth reserves in the world, with 23% of the global total. Yet production of these is still nascent, at just 1% of the global total (Brasil Mineral, 2025).

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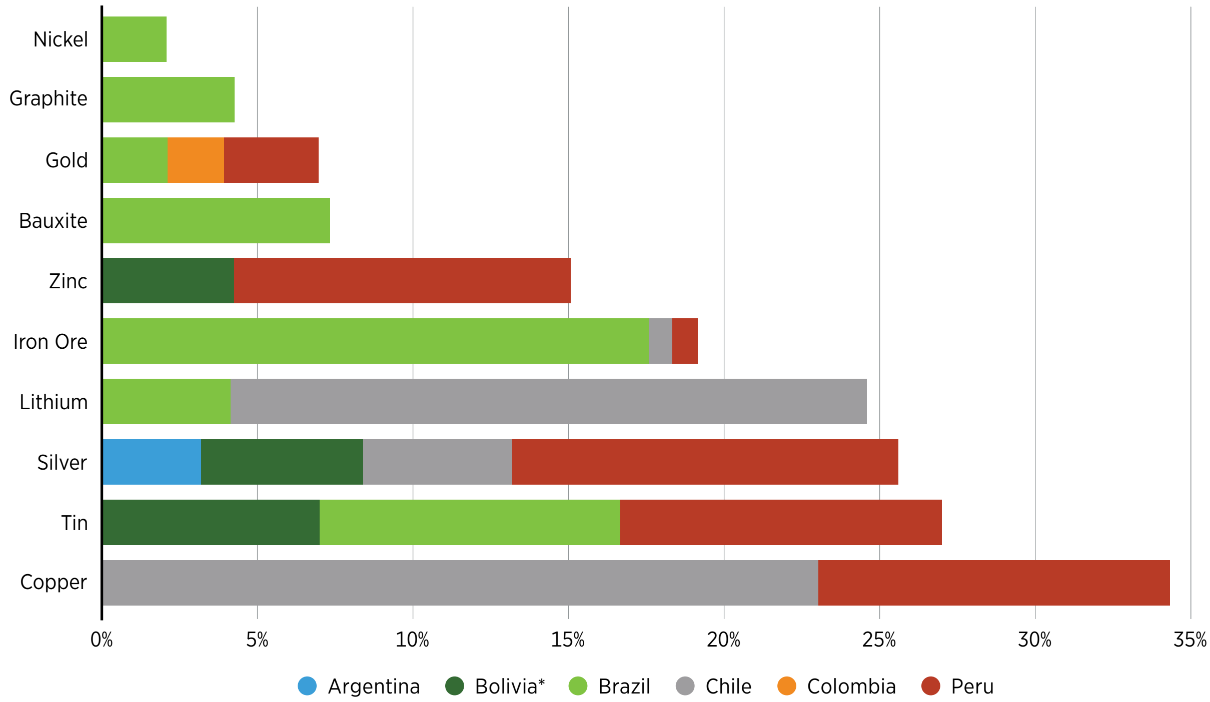
[9] *The Federal Government of Brazil, through its ministries of finance, environment and climate change, mines and energy and development, industry, trade and services, together with the BNDES, Bloomberg Philanthropies, the Glasgow Finance Alliance for Net Zero and the Green Climate Fund, jointly launched the BIP, an initiative to advance Brazil's ambitious climate and development goals. The BIP will initially focus on three sectors: 1) nature-based solutions and the bioeconomy; 2) industry and mobility, catalysing decarbonisation efforts in sectors such as steel, aluminium and cement, electric urban mobility and green fertilisers; and 3) energy, supporting efforts to enable off-grid solar, smart grids, offshore wind energy industries, sustainable fuels, agricultural bio-inputs, low-carbon hydrogen, energy efficiency and critical minerals (GFL, 2024).*

In exploiting the great opportunity such reserves present, however, the region must also address social and environmental concerns. In the past, copper mining, for example, has led to environmental degradation, such as fresh water depletion in Chile's Atacama Desert, along with the displacement of local and Indigenous communities. Mining has also led to the loss of cultural sites, such as in the Cordillera del Cóndor region of Ecuador in 2014 (OECD, 2022a).

**Figure 1.16** South America's contribution to global mineral supply, by country, 2024




**Source:** (USGS, 2025)

**Note:** * The Plurinational State of Bolivia

## Lithium

Batteries dominate lithium usage, with this critical mineral a key component in light-weight vehicle batteries in particular. According to IRENA's WETO 2024 analysis, under the PES the current number of electric and plug-in hybrid light passenger vehicles will increase sixfold by 2030, while under the DES, the number increases ninefold (IRENA, 2024a). Lithium production therefore needs to grow accordingly (ECLAC, 2020), with a rapid upscaling in output (Gielen, 2021).

Production of lithium carbonate from brine-based resources accounts for about 40% of world production, with this supplemented by production from ore-based (spodumene) resources. Data from the 2023 US Geological Survey publication indicates global lithium reserves[10] of 26 Mt, along with 98 Mt in lithium resources,[11] more than half of which are brine based and located in the "lithium triangle" of Argentina, the Plurinational State of Bolivia and Chile. The remainder are largely spodumene ore based and located in Australia, Canada, China and the United States (USGS, 2023a). Both types of production are expanding rapidly, yet brine-based lithium production entails significant groundwater drainage, making it currently unclear as to what extent this method of production can expand in the desert areas of South America where it is currently practised (Gielen, 2021).

In Argentina, there are currently two projects producing lithium, along with eight more at different stages of exploration and construction (Bellato, 2022). Argentina, the Plurinational State of Bolivia and Chile are also currently trying to co-ordinate their production (Muñoz Lima, 2022).

## Copper

Copper for electric wiring plays a key role throughout power production, transmission and use. As demand for electricity is set to increase substantially, demand for copper will also rise. Globally, copper resources are adequate for this, yet the quality of copper ore resources is decreasing (Gielen, 2021). Copper is found in two main types of deposit: 1) porphyry deposits, which account for about 60% of the world's copper; and 2) sediment-hosted strata bound copper, which accounts for about 20%. In the first of these, copper ore minerals are disseminated in igneous intrusions, while in the second, they are concentrated in layers within sedimentary rocks. The remaining 20% of the world's copper deposits are located in other types of geological formation (Gielen, 2021).

According to the 2023 US Geological Survey, the world has 890 Mt of copper reserves and 2 100 Mt of copper resources, (USGS, 2023b). Some 30% of the world's copper reserves are located in Chile and Peru, while Chile alone hosts around a quarter of today's world primary copper production (Gielen, 2021).

## Minerals: Regional strategies

Over the past two decades, the South American region has attracted close to one quarter of the world's exploration investment in the non-ferrous metals mining sector (ECLAC, 2023). Foreign direct investment project announcements have tended to concentrate on Brazil, Chile and Peru, while gold, silver and copper have attracted the most investor attention.

The recent period has also seen the development of international and regional alliances aimed at building capacity and enabling technology transfer. This development has concentrated on two areas: renewable energy development, such as wind and hydrogen, and the production of minerals, such as lithium, in support of renewable energy. As of 2022, a new lithium partnership is being considered between Argentina, Bolivia, Chile and Mexico to collaborate in the exploration, exploitation and development of new technologies (Reuters, 2022).

[10] *The USGS defines "reserve" as "that part of the reserve base that could be economically extracted or produced at the time of determination." (USGS, 2022).*

[11] *The USGS defines "resource" as "a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible." (USGS, 2022).*

## 1.3.5 Carbon taxes in South America

South American economies have been slow to implement environmental taxes, but these and price-based policy instruments are gaining greater prominence. These types of policies include giving price signals to guide consumer decisions, incentivising firms and households to consider the environmental costs of their behaviour. The possibility of an integrated carbon market may also help regional development, bringing new alternatives to resource decarbonisation and liquidity for the regional market. Steps towards this could include a lower carbon tax (although one still higher than today's real-world levels), combined with stronger international collaboration.

One key challenge is that the tax revenues of Uruguay, Chile, Argentina, the Plurinational State of Bolivia, Paraguay, Brazil, Colombia, Peru and Ecuador averaged just 0.87% of GDP in 2020 – well below the estimated global average of 2.0% (OECD, 2022b).

In addition, up to 2024, Argentina, Chile, Colombia and Uruguay were the only countries within the region that had introduced carbon taxes. Colombia and Chile have also set a timeline to develop an ETS in the next few years ('Carbon Pricing Dashboard', n.d.; World Bank, n.d.b). In November 2024, Brazil adopted Law No. 15042, which created the Brazilian Greenhouse Gases Trading System. This allows companies to offset their emissions through the purchase of carbon credits associated with environmental initiatives. Brazil, meanwhile, has not yet imposed an explicit price on carbon.

## 1.3.6 Natural gas: An energy transition carrier in South America?

According to OLADE, within the Latin American and Caribbean region, natural gas is widely considered to be a transitional fuel, especially in the context of emissions reduction targets and energy security needs (OLADE, 2024b). OLADE statistics show that region has approximately 8 000 billion $m^3$ of natural gas in proven reserves. This represents around 4% of the global total (OLADE, 2024b). Within South America, several countries, such as the Plurinational State of Bolivia and Argentina, are rich in fossil gas reserves and rely on natural gas for both domestic consumption and fiscal revenues.

In the Plurinational State of Bolivia, natural gas is one of the main contributors to the national energy mix and generates major export revenues through sales to Brazil and Argentina. Colombia's Law 2128 of 2021 establishes natural gas as critical to the national interest. It also promotes the uptake of natural gas-powered vehicles, mandating that for the next ten years, 30% of new public transit fleet additions in the country be powered by natural gas (Cabrales and Delgado, 2022; Congress of the Republic of Colombia, 2021). Meanwhile, as Chile phases out coal, it is converting some power plants to natural gas. Elsewhere, Argentina has excluded natural gas from the carbon tax it introduced in 2018 in order to maintain its affordability and role in the energy system. In addition, Colombia and Argentina are pursuing blue hydrogen production based on natural gas combined with carbon capture.

In terms of infrastructure, recent years have seen progress in some major regional natural gas projects, along with some new announcements. Developments include: the commissioning of the first stage of the Presidente Néstor Kirchner pipeline in Argentina, which will allow full exploitation of the Vaca Muerta field; new reserves in the Plurinational State of Bolivia; three major projects for supply expansion in Brazil; and expansion of the distribution network in Peru (OLADE, 2024b). In addition, Uruguay has announced progress with the Hydrogen for You (H24U) project. A pilot initiative for this will see the injection of green hydrogen into the existing natural gas grid in order to assess possibilities for the future integration of green hydrogen at scale into grid decarbonisation efforts (OLADE, 2024b).

In 2023, natural gas accounted for approximately 18% of the region's TPES, based on an aggregate of the South American countries' energy balances that are made publicly available. With respect to electricity generation, natural gas-fired thermal power plants covered 18% of the region's installed capacity and 14% of its electricity production that same year. On the demand side, natural gas accounted for 11% of the region's total final consumption (energy and non-energy uses). Argentina was the largest consumer of this fossil fuel within the region, accounting for around 39% of the 2.2 EJ consumed in 2023.

According to this analysis of the South American region, under existing energy plans, natural gas maintains a similar share of TPES as today, at around 16% by 2050. Under the DES, however, the share taken by natural gas falls to less than 5%, as a greater and more effective decarbonisation of the overall energy sector is pursued via the exploitation of the region's vast potential in variable renewables and sustainable bioenergy. This small natural gas share in the DES corresponds mainly to technologies based on natural gas in end-use sectors, specifically industry, besides input requirements for electricity generation.

The findings of this analysis show the importance of proper planning regarding the expansion of infrastructure, to avoid the creation of stranded assets.

## 1.4 TOTAL SYSTEM COSTS OF ENERGY TRANSITION PATHWAYS

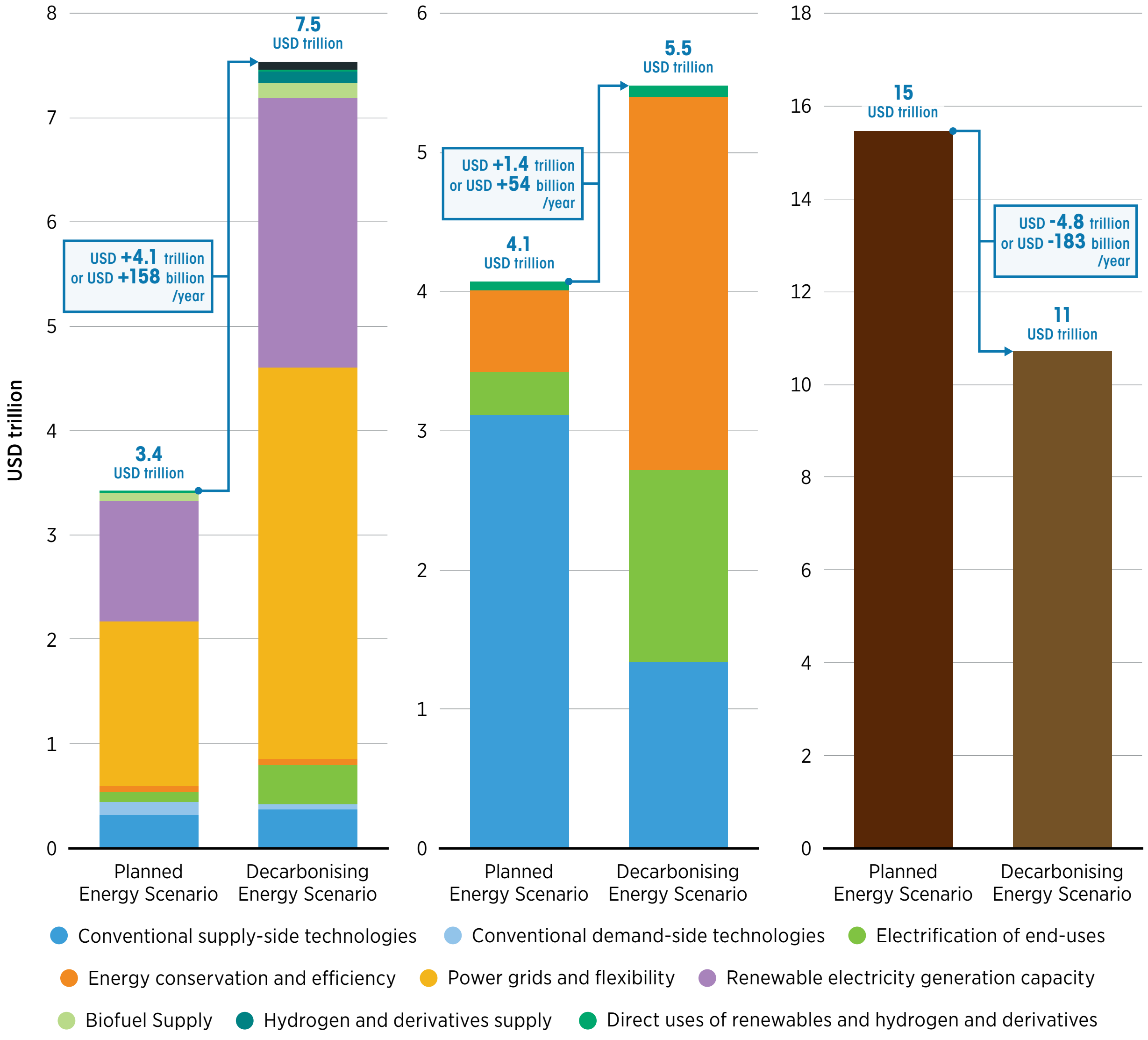
The regional energy transition outlook for South America includes three modelling components in terms of investment and costs:

- **Investment**, referring to the capital costs of infrastructure, *e.g.* industrial production plants, power plants and grids, fuelling and/or charging stations for transport sector
- **Expenditures** requirements to acquire technologies/devices for the end-use sectors, *e.g.* vehicles in transport, boilers or cookstoves in buildings
- **Fuel costs** considering the energy carriers' consumption and projection of prices based on references of the countries, *e.g.* costs due to diesel or gasoline consumption in transport, costs of electricity consumption in all sectors

Figure 1.17 presents the cumulative investment, expenditure and fuel costs of the main scenarios over the period 2025-2050. The investments and expenditures are categorised by technological avenue, following the KPIs defined in the outlook framework. The implementation of the measures identified in the countries' energy plans would account for USD 7.5 trillion in investments and expenditures (USD 3.4 trillion and USD 4.1 trillion USD, respectively), which translates into USD 288 billion/year. Nevertheless, most of these investments and expenditures still correspond to "conventional" technologies in both supply and demand-side, referring to units or technologies based in fossil fuels and/or no implementation of energy efficiency standards.

In contrast, the DES depicts higher investment and expenditures requirements in the period 2025-2050, estimated at USD 13 trillion (USD 7.5 trillion in investments and USD 5.5 trillion in expenditures), or USD 501 billion/year. Compared to the PES, IRENA's decarbonisation pathway for the region considers less deployment of conventional technologies, around quadruple the investment in electrification of end-uses, more than double the needs for the renewable electricity generation and same factor to cover the corresponding power grids and flexibility infrastructure. Investments in biofuels and hydrogen supply and carbon removals facilities are also estimated to complement the energy transition budget, as shown in Figure 1.17.

**Figure 1.17** South America's cumulative investments, expenditures and fuel costs (USD trillion) under the PES and DES, 2025-2050




**Notes:** Investment refers to capital costs in infrastructure (*e.g.* power plants and grids, manufacturing plants, charging stations), expenditure considers acquisition costs of technologies in end-use sectors, and fuel costs are related to energy carriers for end-use sectors; DES = Decarbonising Energy Scenario; PES = Planned Energy Scenario.

Furthermore, the analyses of investment and expenditures in the region for both the PES and DES in the period 2025-2050, denoted the level of effort required from the end-use sectors side, as results showed shares of over 40% for the expenditure component (around 55% in the PES and more than 40% in the DES). This highlights the needs for financing mechanisms for the final users in order to reach the penetration levels of efficient and cleaner technologies required for the energy transition of the region.

Finally, in terms of the fuel costs analysis, Figure 1.17 shows the impact of the measures applied in the DES, with a difference of around 30% less compared to the estimated fuel costs in the PES, or USD -4.8 trillion over the period 2025-2050. Evaluating the reduction of fuel costs in the DES, against the extra investments and expenditures required for the scenario, the estimations denote an overall difference of only +3.4% compared to the PES, with the benefits of a cleaner energy matrix, a more integrated infrastructure with efficient use of the region's resources ensuring energy security, improvements in welfare while supplying the expected domestic demand and the international perspectives (*e.g.* green products, hydrogen) of the South American countries over the study period.

## 1.5 OVERVIEW OF THE ENERGY TRANSITION FINANCE LANDSCAPE IN SOUTH AMERICA

In 2024, energy transition investments in the region reached USD 58 billion – an increase of 23% on the USD 47 billion invested in 2022-2023[12]. However, the region still only accounted for 2.5% of global energy transition investments.

Renewable energy accounted for USD 40 billion of energy transition investment in the region in 2024 – the largest share, with 70% of the total. This was up from 67% in 2022-2023, when USD 31.2 billion was invested. The 2024 figure accounted for 5% of total, global renewable energy investments that year.

When renewable energy is excluded from the 2024 figures, investment in other transition technologies in the region totalled USD 18 billion – a 12% increase on 2022-2023. Brazil alone accounted for 85% of these investments, a figure up from 78% in 2022-2023. The largest share of these other regional investments went to power grids (USD 12 billion) (BNEF, 2025a), EVs and charging infrastructure (USD 5 billion) (BNEF, 2025a), and energy storage (USD 1 billion) (Climate Policy Initiative, 2025).

In 2022-2023, USD 1.8 billion in energy efficiency investments were made across Brazil, Chile, Colombia, Argentina and Peru. There were also small amounts invested in green hydrogen and CCS.

In 2024, power grids accounted for more than half of all investments (67%) in the region, yet this represented only 3% of global grid investments. Brazil accounted for 91% of the total power grid investment in South America, up from 88% in 2022-2023. This continued concentration aligns with the country's leading position in renewable energy deployment in the region (see details in the renewable energy subsection below).

In 2024, electrified transport represented 26% of the region's investments in transition technologies, when renewable energy is excluded. This was a figure equivalent to 0.6% of global investments in this mode of transportation. Brazil accounted for most of the region's investment in this area, with 91% of the regional total that year – up from 84% in 2022-2023. This continued dominance was driven by policies such as the Green Mobility and Innovation Programme (Programa Nacional de Mobilidade Verde e Inovação [MOVER]) and other tax relief incentives (Cieplinski *et al.*, 2025; Vilela, 2025), as well as major private sector developments, such as vehicle manufacturer Stellantis' USD 6.1 billion investment in upgrading production.

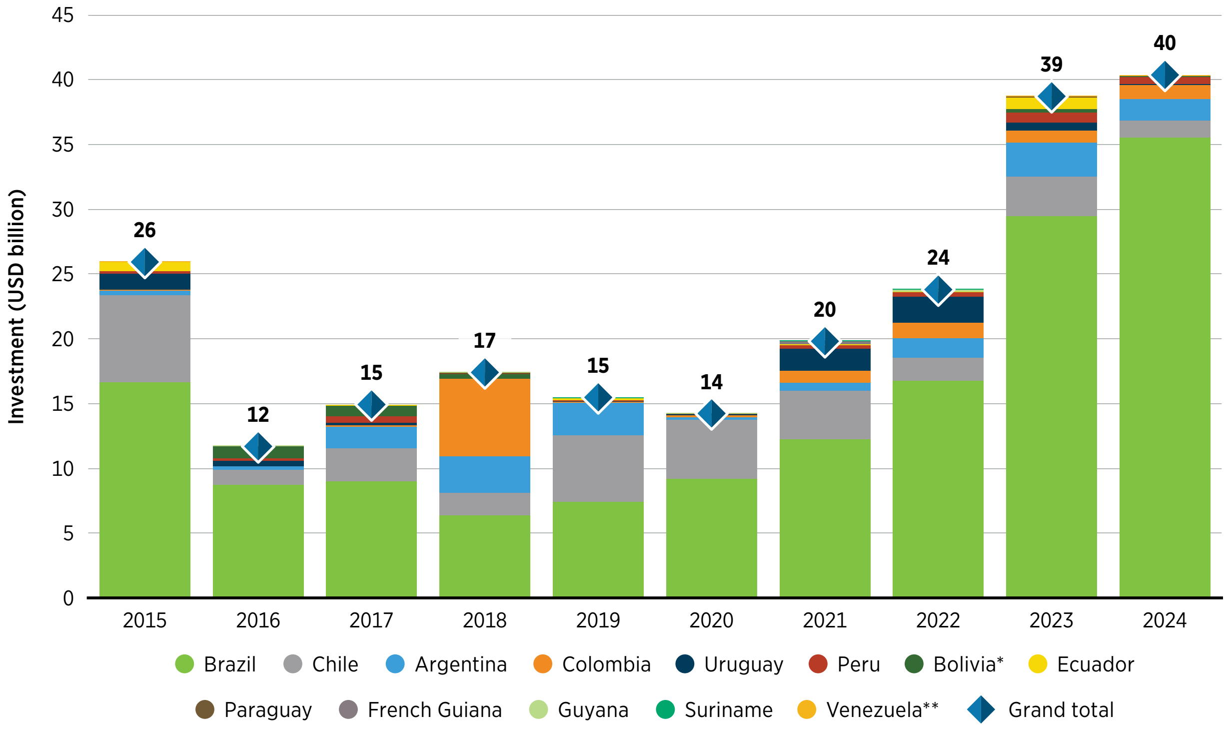
Compared to the 2022-2023 period, regional investments in energy storage decreased by 27% in 2024, accounting for 6.3% of the region's investment in technologies other than renewables. This was still higher than the global average, however, which was 2%. Chile accounted for 98% of regional energy storage investments in 2024, similar to its 2022-2023 level. Despite the overall decline, Chile's sustained investment reflects its efforts to reduce transmission bottlenecks (IEA, 2024a), especially in challenging areas such as its resource-rich northern region (Societe Generale, 2025).

[12] *Comparisons with previous years are based on average annual investments over two-year periods (e.g. 2022/2023) to smooth short-term fluctuations caused by large project commitments in individual years.*

## 1.5.1 Overview of regional renewable energy investments

As stated earlier, renewable energy investments in South America have surged in the last few years, increasing 29% between 2022-2023 and 2024 from USD 31.2 billion to a peak of USD 40 billion[13] (see Figure 1.18). After a drop in 2016 and relatively low commitment levels between 2016 and 2020, investments began to rebound post-2020 and have since seen consistent increases. Despite this growth, however, the region continues to account for a small share of global investments (5% in 2024, up from 4.7% in 2022-2023). This share remains small compared to other major markets such as China (which accounted for 44%), Europe (17%) and North America and Oceania (15%) in 2024.

**Figure 1.18** South America's total renewable energy investments by country, 2015-2024 (USD billion)




**Notes:** Investments for 2024 are estimates based on 2023 data from the Climate Policy Initiative (CPI) and 2023–2024 trends from BNEF; * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela.

As renewable energy projects are capital-intensive, there is a need to build regional frameworks and mechanisms that can help reduce the cost of capital and mitigate risks for infrastructure investments. The share of financing in the LCOE increases as the weighted average cost of capital (WACC) gets higher (IRENA, 2025a). In 2024, for example, the WACC values for the countries covered in South America ranged between 8% and over 15%, with the share of financing in LCOE ranging between 50% and 70%.

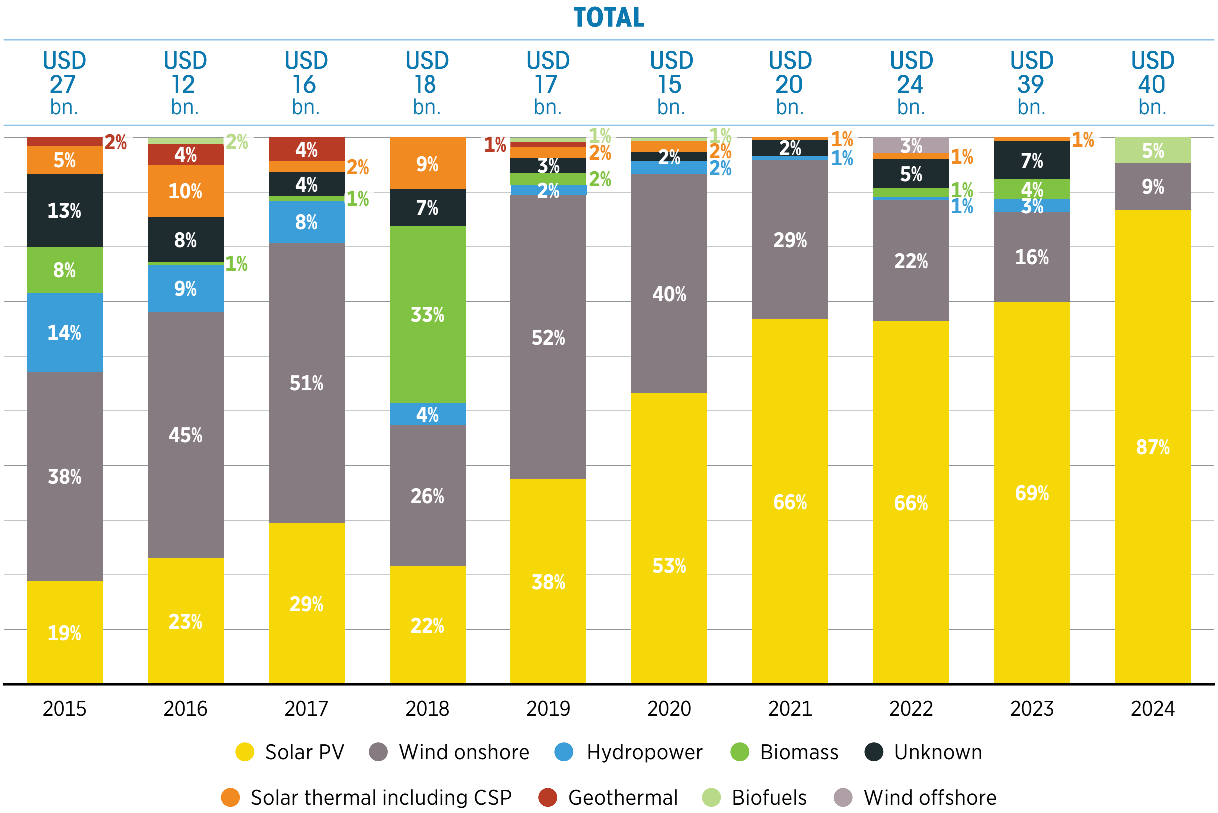
The following sub-sections present an overview of the region's renewable energy investments seen from four different perspectives: technology, country, source and instrument.

[13] *Data for 2024 is from preliminary estimates derived by applying Bloomberg New Energy Finance 2024 sector-level growth rates (relative to its 2023 figures) to the Climate Policy Initiative's 2023 Global Landscape of Climate Finance data.*

## Investment trend by technology

In the 2022-2023 period, solar PV led the region's renewable energy investments, making up 68% of the total, or USD 21.3 billion (see Figure 1.19). Preliminary data suggests that in 2024 investments further concentrated, with solar PV's share surpassing 85%. This figure was primarily driven by consistent growth in Brazil, fuelled by its booming small-scale distributed solar market. It was also supported by net-metering incentives and strong demand from households and businesses (Ellis, 2024). In 2022-2023, Brazil alone accounted for 78% of regional solar PV investments and an estimated 90% in 2024.

**Figure 1.19** Share of annual renewable energy investments in South America, by technology, 2015-2024 (USD billion)




**Notes:** Investments for 2024 are estimates based on 2023 Climate Policy Initiative data and 2023-2024 trends from BNEF. The 'unknown' category represents the proportion of renewable energy investment that could not be attributed to a specific technology; CSP = concentrated solar power; PV = photovoltaic.

Investment in onshore wind in the region has fluctuated over time, reaching USD 5.7 billion in 2022-2023, when it accounted for 18% of the regional total. This was down from 33% in 2020-2021. Preliminary data suggests that this share dropped further in 2024, to below 10%. The overall regional trend in onshore wind is again driven by Brazil, which consistently accounts for the majority of regional investments – 74% in 2022-2023, and an estimated 61% in 2024. Recent investment growth in the country was likely pushed by a rush to secure expiring transmission fee incentives (EnergyNews, 2024). This, however, is expected to slow unless grid expansion and upgrades are accelerated, as ongoing transmission bottlenecks and curtailment risks threaten growth (Wood Mackenzie, 2025).

Other renewable energy technologies – including bioenergy, hydropower, solar thermal, geothermal, marine and offshore wind – have received minimal investment in recent years, accounting altogether for just over 7% of the regional total in 2022-2023, or USD 2.2 billion. This underscores a continued concentration of financing in solar PV and onshore wind, in line with global trends.

### Investment distribution across South America

In recent years, Brazil has consistently been the region's largest renewable energy market. In 2022-2023, it captured USD 23 billion in renewable energy investments, or 74% of the South American total. This was up from 62% in 2020-2021. Preliminary data for 2024 shows this share to have risen again, to around 88%. Indeed, growth in investment in renewables in Brazil has been positive (and accelerating) since 2018. This has been driven mainly by a boom in small-scale solar PV investments (Ellis, 2024) and a strong enabling environment. The latter has included mechanisms such as long-term auction planning, regulatory stability and the active role of regulatory bodies such as the National Electrical Energy Agency (Agência Nacional de Energia Elétrica [ANEEL]) and the Energy Research Office (Empresa de Pesquisa Energética [EPE]), as well as investors such as BNDES (WEF, 2024). Looking ahead, Brazil's recent Fuel of the Future Law (Lei dos Combustíveis do Futuro) is expected to boost investments further in emerging technologies such as sustainable aviation fuel (SAF) and biomethane (IEA, 2025a).

Chile, Argentina and Uruguay also remain key destinations for investment in the region, although in recent years, this has been at a lower level than Brazil. Together, Chile, Argentina and Uruguay accounted for 18.5% of the regional total in 2022-2023, with this falling steeply to an estimated 7% in 2024, likely due to a combination of macroeconomic headwinds, grid constraints, and policy and regulatory risks. In 2022-2023, investments in Argentina and Uruguay grew by 376% and 49% respectively, year-on-year, though preliminary data suggests that this trend reversed in 2024. Investments in Chile dropped by 42% in 2022-2023 – a trend that seems to have continued in 2024. This decline is in partly attributable to increasing grid transmission bottlenecks (BNEF, 2025b), though the country has recently ramped up investment in storage and battery systems to alleviate these issues (IEA, 2024a).

Elsewhere in the region, Peru, Ecuador, Colombia, the Plurinational State of Bolivia and Guyana all saw notable increases in investment in 2022-2023 compared to 2020-2021. However, these countries still only received a combined total of USD 2.3 billion in 2022-2023 – 7.4% of the total regional inflow for the period. Ecuador showed the highest growth, with an almost 100 times increase in renewables investment, from USD 5.3 million in 2020-2021 to USD 506 million in 2022-2023. This was due to an increase in investments from multilateral development finance institutions (DFIs) in 2023, including the Development Bank of Latin America and the Caribbean, the World Bank and the European Investment Bank.

On the other hand, Paraguay and French Guiana saw declines in their renewable energy investments in 2022-2023, with these falling 58% and 99%, respectively, year-on-year. French Guiana experienced a notable drop, with investment falling from USD 101 million in 2020-2021 to just USD 1.2 million in 2022-2023. This was likely due to a decrease in investor confidence following the cancellation of the EUR 200 million Maia solar project – which was axed due to a lack of support and revised energy policies – along with broader uncertainty over the territory's renewable energy planning (Ajayi, 2025).

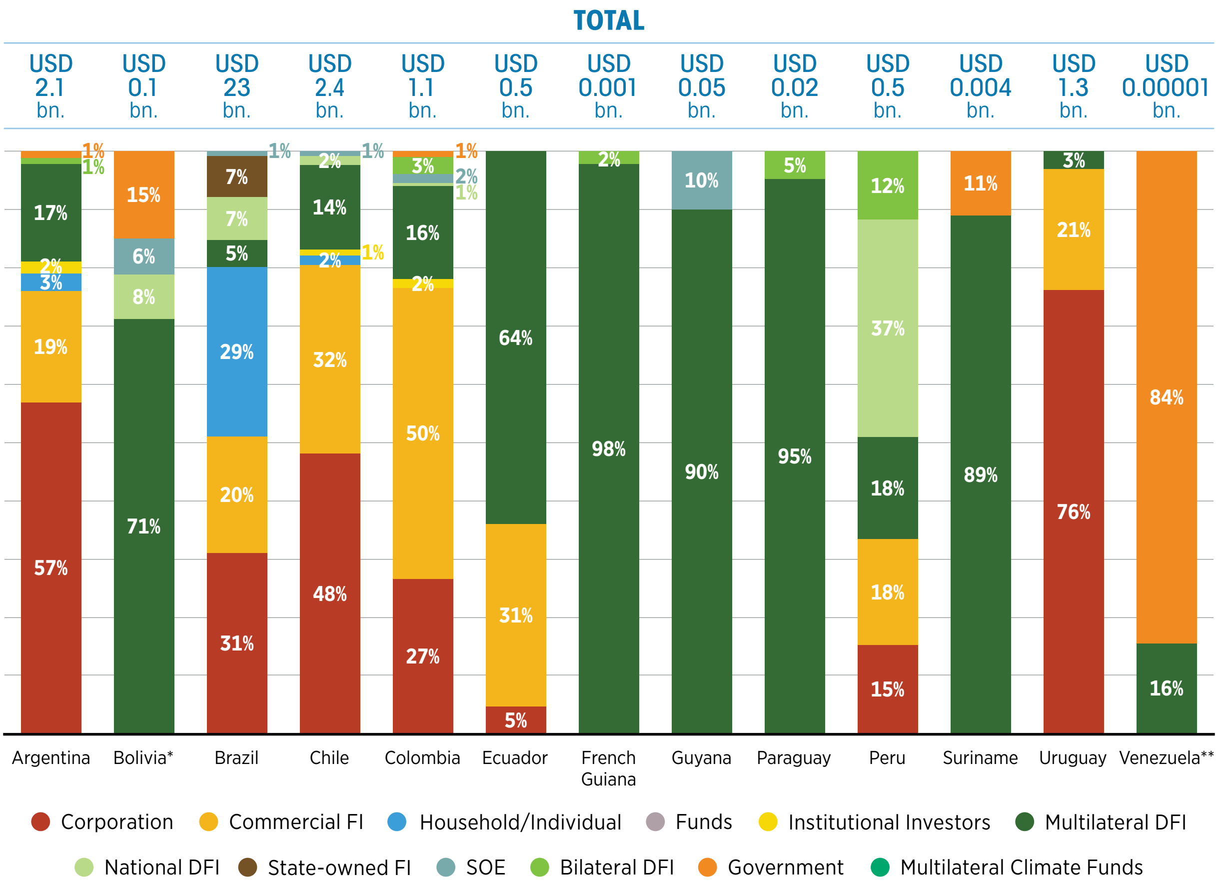
## Sources of renewable energy investment

Due to a lack of preliminary data on investment by source for 2024, the analysis in this section only covers the period up to 2022-2023 (see Figure 1.20).

In 2022-2023, private sector capital dominated renewable energy investments across South America, accounting for 79% of total renewable energy investment. Private sector dominance was observed in Brazil, Argentina, Chile, Colombia and Uruguay, which together accounted for 96% of total private renewable energy investments in the region during the period. In the Plurinational State of Bolivia, Ecuador, Peru, Suriname, French Guiana, Paraguay and the Bolivarian Republic of Venezuela, public sources accounted for almost all of the capital invested.

Corporations accounted for 35% of total private sector investment in 2022-2023, while commercial financial institutions accounted for 22% and continued to be the leading actors in Brazil, Argentina, Chile, Colombia and Uruguay. This reflected a consistent trend from 2020-2021 and previous years. Multilateral DFIs were the main capital providers for all the other regional countries during the period, with the exception of the Bolivarian Republic of Venezuela. In 2022/2023, 84% of investments came from foreign governments in North America, Oceania and Europe.

**Figure 1.20** South America's investment in renewable energy, by investor type and country, 2022-2023




**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela.

In 2022-2023 Uruguay also stood out, with 76% of its renewables investment coming from corporations, directed primarily toward solar PV projects. By the end of 2023, the country had approximately 297 megawatts (MW) of installed solar PV capacity. It has also recently launched a tender for a 75 MW solar park (Ini, 2025), underscoring the country's continued commitment to expanding its solar energy deployment.

Elsewhere, several regional countries remain heavily reliant on public and development finance. In 2022-2023, for example, French Guiana secured renewable energy investments of USD 2.4 million through a combination of project-level debt, equity and grants, with some 98% of this coming from multilateral DFIs and the remainder from bilateral DFIs. This was likely due to its status as a French overseas territory, which makes it ineligible for sovereign lending.

Other countries in the region also depended heavily on multilateral DFIs during the period under examination. Investment from such institutions accounted for 95% of investment in Paraguay, 90% in Guyana and 89% in Suriname. Peru was similarly reliant on public and development finance, though to a lesser extent, with these sources accounting for 67% of its total in 2022-2023. Over half of this share – an amount equivalent to 37% of Peru's total renewable energy investment of USD 400 million – came from a Chinese national DFI for hydropower and bioenergy projects.

In 2022-2023, within the region, direct investments made by governments in new renewable energy assets[14] remained limited, at 0.3% of the total. In the Bolivarian Republic of Venezuela, however, they accounted for 85%. This was largely driven by governments in Switzerland, Germany, the United States and New Zealand. Venezuela's reliance on government funding is likely shaped by its state-led economic structure, which favours government financing over private investment. This is in addition to the country's challenging domestic fiscal environment, which includes high inflation and debt-related pressures (Roy and Cheatham, 2024). This limits domestic capacity and increases reliance on foreign government support.

In the 2022-2023 period, 77% of renewable energy investments in the region came from domestic sources. This trend was, however, heavily influenced by Brazil, where domestic investments accounted for 87% of the total. International finance made up more than 50% of renewable energy investment in all countries except Brazil, Argentina, Uruguay and Colombia. This source also made up more than 90% of renewable investments in six of the 13 countries and jurisdictions covered,[15] underscoring the lack of domestic funding in the region. More than half of the international investments in the region – some 66% – came from Europe, with European commercial financial institutions accounting for 38% of that 66%, European corporations for 29% and European multilateral DFIs for 23%. The remaining international flows came from a more evenly distributed mix of investors based in North America, Oceania and Asia.

[14] *This excludes financial resources committed by governments in policy support measures for renewables (e.g. subsidies).*

[15] *Those countries were Peru, the Plurinational State of Bolivia, Paraguay, French Guiana, Suriname and the Bolivarian Republic of Venezuela.*

## Financing instruments and mechanisms

In 2022-2023, South America saw total impact-driven investments[16] (grants and low-cost project debt instruments, those which have beneficial loan terms in areas such as interest rates, grace periods, maturity and discount rates) reach USD 1.9 billion. This was up from USD 213 million in 2020-2021. This growth was also reflected in the share this type of financing took in total renewable energy investment – a proportion which rose from 1.2% in 2020-2021 to 6% in 2022-2023.

In addition, the 2022-2023 period also saw low-cost project debt dominate impact-driven investments, contributing USD 1.8 billion, or 96%, of the total. Grants made up just USD 77 million, or 4%. National DFIs provided the majority of impact-driven capital (81%), with smaller contributions from multilateral DFIs (15%), governments (2.3%) and bilateral DFIs (1.7%).

From 2013 to 2016, impact-driven investment had a significantly higher share of renewables investment than it does now, averaging 34% over the period. Since 2017, however, impact-driven capital has seen its share remain consistently low. This has largely been due to the low-cost project debt provided by the BNDES. This changed in 2017 with a shift from the subsidised Long-term Interest Rate (*Taxa de Juros de Longo Prazo*) to the more market-aligned Long Term Rate (*Taxa de Longo Prazo*), reducing the concessionality of public lending (World Bank, 2017).

In the 2020-2021 period, Brazil accounted for 54% of the region's total impact-driven capital, with other countries such as Paraguay (17%) and Colombia (12%) capturing the majority of the remaining portion. By 2022-2023, Brazil's dominance had increased sharply, as it received 82% of the region's impact-driven capital, largely provided by the BNDES. This type of capital, however, represented only about 6.7% of Brazil's total renewables investment during those years.

For two South American countries – the Bolivarian Republic of Venezuela and Guyana – impact-driven capital formed the bulk of the renewable energy investments they received during the 2022-2023 period. In the former, 85% of total capital came from this source, with the majority made up of grants largely originating in government-backed inflows from Switzerland, Germany, the United States and New Zealand. In Guyana, some 87% of inflows were grants.

Across the region, profit-driven instruments have continued to account for the majority of investments in recent years, with these reaching USD 29 billion, or 94% of the total, in 2022-2023. This was up from USD 17 billion in 2020-2021, although that period also saw this type of instrument account for a higher proportion of the total, at 99%. This dominance was largely underpinned by private sector actors, particularly corporations, which accounted for 37% of the total. These were followed by commercial financial institutions and households, with 23% each. Altogether, these three accounted for 83% of profit-driven financing. The majority of the remainder came from public actors such as multilateral DFIs (7.8%) and state-owned financial institutions (5.4%). This distribution reflected the limited availability of concessional finance across the region, with many countries facing rising debt distress and macroeconomic pressure (IMF, 2025).

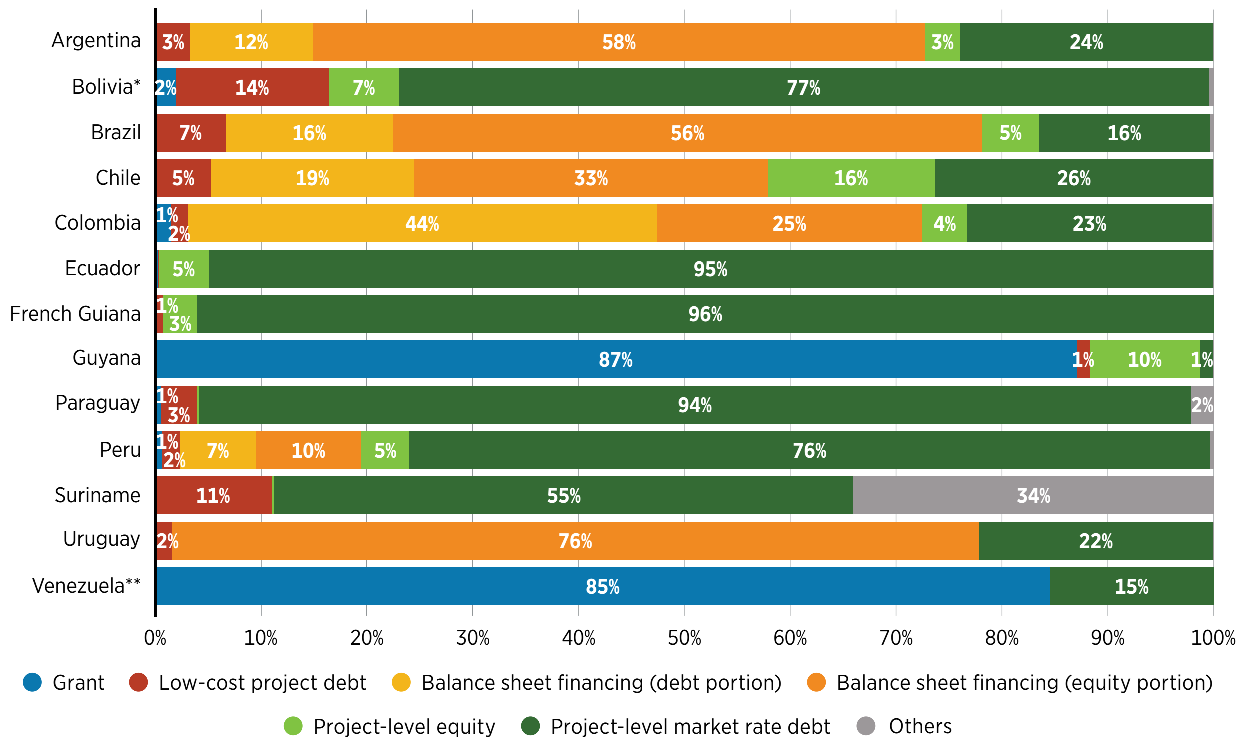
[16] *Low-cost debt as a form of concessional (impact-driven) finance, follows the OECD definition on concessional funds that meet the official development assistance grant equivalent threshold with economic development and welfare as the main objective. "Concessionality" is evaluated by calculating the "grant element", which considers four main factors: the interest rate, the grace period, the maturity, and the discount rate. A loan is deemed concessional if its grant element surpasses 10% for upper middle-income countries, 15% for lower middle-income countries, or 45% for least developed countries and other low-income countries (OECD, 2020). Loans to the private sector need to convey a grant element of at least 25% to be concessional.*

Indeed, the Plurinational State of Bolivia exemplifies this situation. In 2022-2023, 77% of its renewable energy investments were financed through project-level market rate debt (see Figure 1.21). This amounted to USD 208 million and was provided primarily by multilateral DFIs. The largest share came from the Inter-American Development Bank (IDB, n.d.) which financed a rural electrification programme aimed at contributing to poverty reduction through the universalisation of electricity services. While the programme's objectives reflect strong development priorities, Bolivia's reliance on market-rate debt underscores its limited access to concessional finance. With public debt now exceeding 90% of Bolivia's 2024 GDP (Trading Economics, n.d.), this dynamic illustrates how debt-vulnerable countries often face a trade-off between advancing the transition and managing fiscal stability, highlighting the need for greater concessionality and innovative financing models to enable progress without deepening debt risks.

While debt remains essential to scaling renewable energy projects, particularly for capital-intensive assets such as solar PV and wind, the region's underdeveloped financial systems and high capital costs (IEA, 2023c, 2025), along with limited concessional finance, raise concerns about the sustainability of debt-led financing models in countries already facing debt distress.

Brazil's renewable energy financing is heavily reliant on balance sheet structures, particularly equity, with 56% coming from this source in 2022-2023. This equity was accounted for mainly by corporations (26%) and households (29%). In addition, some 16% of financing was accounted for by debt during the same period, with this largely provided by commercial financial institutions. These accounted for 11.4% of the total. This dominance of balance sheet structures reflects a preference for investors, such as utilities and major developers, to use their corporate financing for projects, rather than raising funds through project finance vehicles.

**Figure 1.21** Share of investment in renewable energy in South America, by financial instrument and country, 2022-2023




**Notes:** "Others" represent the portion of renewable energy investment not associated to any of the categories defined, as per availability of detailed data in certain countries; * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela.

# 02

# ENERGY TRANSITION PATHWAYS: **TRANSPORT**

## INSIGHTS AND RECOMMENDATIONS FOR THE ENERGY TRANSITION IN TRANSPORT

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ South America's transport sector remains heavily fossil-fuel dependent (around 90% of final energy consumption in 2023). Under the DES, renewables reach 19% by 2030 and 83% by 2050 driven by the deployment of biofuels, electrification, and smart mobility. | ★ Promote intermodal transport, clean mobility, and smart logistics to enable an efficient, low-carbon transport system. Ensure a just transition through worker retraining and new skills programmes. |
| ★ Road transport dominates the sector's energy use (94% in 2023), with emissions falling by 86% in the DES (vs. PES) by 2050. Clean technologies (flex-fuel, hydrogen, and electric vehicles) could reach 97% of the total fleet by 2050. | ★ Introduce tax and fiscal incentives for clean vehicles; electrify new public transport fleets; promote fleet renewal, preferred access for clean vehicles and public procurement of electric vehicles (EVs). |
| ★ Biofuels remains a cornerstone of regional decarbonisation, supported by blending mandates and local feedstock potential. In the DES, bioenergy's share in road transport could reach 34% by 2050. | ★ Strengthen biofuel mandates and regional integration, support local production and biorefineries, and provide tax incentives and financing mechanisms for sustainable biofuels. |
| ★ Natural gas serves as a transitional fuel in some countries but declines sharply under the DES (to 2% of demand by 2050). | ★ Provide short-term fiscal support for natural gas vehicle conversion while prioritising a shift to bioenergy and electrification. |
| ★ Hydrogen offers a niche solution for heavy-duty road transport, powering about 1% of the vehicle fleet under the DES as electrification becomes dominant. | ★ Offer targeted incentives for hydrogen trucks, promote green hydrogen production, and support investment platforms and public procurement for early deployment. |
| ★ Electric vehicle uptake will require a fivefold increase in charging infrastructure under the DES compared to the PES by 2050, with home chargers accounting for around 85% of units. | ★ Incentivise investment in charging infrastructure through tax exemptions, import tariff reductions, and public procurement, while standardising batteries and charging systems. |
| ★ Aviation decarbonisation will rely on sustainable aviation fuels (SAFs). The DES foresees 70% of aviation fuel demand met by SAF by 2050, aligned with global aviation targets. | ★ Establish SAF blending mandates, tax incentives, and funding for R&D, feedstock analysis, and refinery development. Promote regional collaboration and industrial partnerships. |
| ★ Cumulative investments and expenditures for transport decarbonisation amounts to around USD 5 trillion under the DES (2025-2050), cutting emissions by over 85% compared with the PES by 2050. | ★ Mobilise concessional finance and credit for low-carbon infrastructure, expand and modernise rail networks, and support R&D to strengthen regional transport connectivity. |

## 2.1 OVERVIEW OF THE TRANSPORT SECTOR IN THE REGION TODAY

Transportation of people and goods is a vital activity around the world and South America is no exception. In 2023, transport accounted for more than one-third of the region's end-use sector energy demand, according to public statistics available in the energy-related institutions of the countries. In terms of the sector's energy mix, in 2023, fossil fuels accounted for 87% of the sector's energy consumption, followed by bioenergy, with 13%, and electricity, with less than 1%. Given this dominant use of fossil fuels, the sector is also a major contributor of $CO_2$ emissions. Indeed, transport accounted for 40% of the region's energy-related emissions in 2023.

In terms of specific countries, the top three biggest economies – Argentina, Brazil and Colombia – together account for 73% of regional sectorial energy consumption. This is led by Brazil, with 53% of the total, followed by Argentina with 11% and Colombia with 9%.

In terms of measures, strategies and declarations regarding transport sector decarbonisation, to date, countries have primarily targeted the following:

- In most countries, electromobility has been promoted as the preferred solution in light vehicles and buses. Brazil, the global leader in bioenergy use in transport, is also set to continue promoting bioenergy in flex-fuel fleets, complemented by electrification.
- Key initiatives in road cargo include modernisation of truck fleets to allow higher efficiencies; the promotion of gasification (through compressed/liquefied natural gas in Argentina and the Plurinational State of Bolivia); and electrification of small trucks in urban areas.
- In Argentina and Colombia, higher fuel economy standards have been introduced for light vehicles and heavy-duty trucks.
- An increased role for biofuels has been facilitated by blending mandates, with Brazil reinforcing its leadership in this area via some ambitious plans for bioethanol and biodiesel (Ministério de Minas e Energia do Brasil, 2024).

This chapter provides the main findings and key messages from the analysis of the domestic transport sector in South America. The analysis covers four sub-sectors: road (passenger and freight), rail (passenger and freight), air (domestic aviation) and water transport (including inland waterways and coastal shipping). It also addresses three guiding questions:

- What is the projected impact of transport activity on energy demand up to 2050?
- Are the strategies being implemented across countries aligned with regional decarbonisation objectives by mid-century, and what opportunities exist for greater cross-country synergies?
- What are the main policy priorities requiring attention from decision makers?

Finally, insights related to international bunkering fuels are addressed in the supply-side chapters, notably Chapter 6 (bioenergy, including aviation and maritime biofuels) and Chapter 7 (hydrogen, focusing on production and trade). These analyses are closely linked to the broader energy sector decarbonisation pathways explored throughout the report.

## 2.2 TRANSITION ROADMAPS FOR THE TRANSPORT SECTOR

In terms of GDP, the region's economies are expected to grow at a compound annual rate of 2.4% between 2023-2050. Both passenger and cargo transportation are projected to follow this trend, with transport sector energy consumption under the PES seeing a 75% growth rate over the same period, reaching around 12 EJ in 2050.

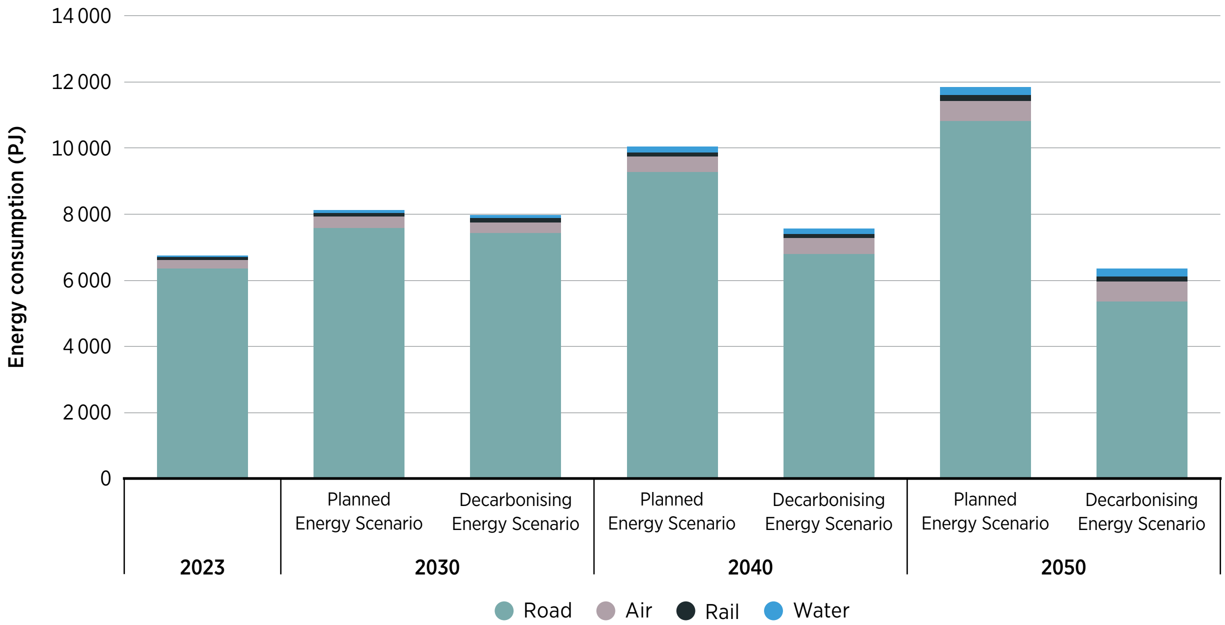
Under the DES, a hybrid strategy for regional transport decarbonisation is foreseen. This involves the wide penetration of electromobility and a higher utilisation rate for biofuels. The DES also foresees a sustainable pathway for the sector via consideration of country-specific technological preferences and clean energy potential, all in alignment with national strategies. A rapid uptake of EVs is set as the core measure across all countries, especially in light vehicles for road transport, with pure EVs as the preferred technology.

In terms of biofuel-based technologies, the DES includes the wider introduction of flex vehicles, following success with these in Brazil. Stringent blending mandates for road transport are also foreseen in Brazil, Argentina, Colombia and Paraguay as an effective way to further harness the high potential of this resource throughout the region. Furthermore, bioenergy in domestic aviation is to be realised through biojet mandates. Further electrification in railways and the conservative introduction of electrification in water transportation would help to cut emissions considerably across these transportation modes over the period up to 2050.

The compound effect of all these measures would be a decrease of over 85% in the sector's energy consumption by 2050, when compared to the PES. When compared to the 2023 base year, the cut would be approximately 80%.

The TFEC by mode of transport under the PES and DES over the 2023-2050 period can be seen in Figure 2.1. Road transport is the leading mode throughout, accounting for 94% of final consumption in the base year, followed by air transportation, with 4%, and the remaining modes with 2%. According to the national plans reflected in the PES, these shares are not expected to change much during the study period. In the DES, the share taken by road transport declines to 84%, while air transport increases to 10%.

**Figure 2.1** Final energy consumption in the transport sector under the PES and DES, by mode, 2023-2050

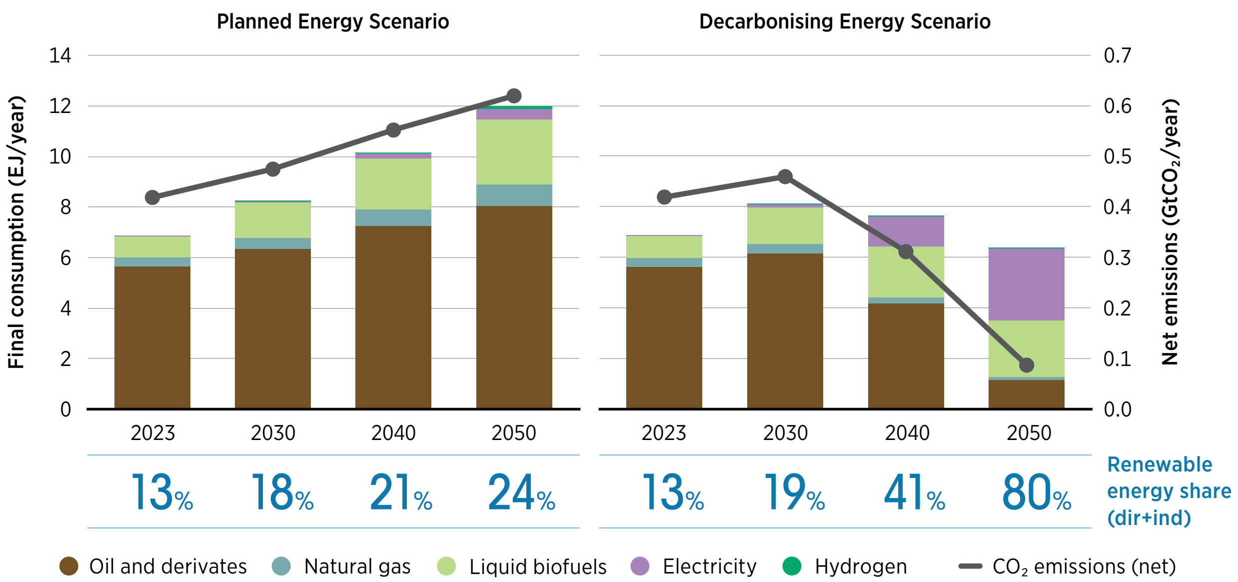



**Note:** PJ = petajoule.

Under the PES, the transport sector energy mix sees a decrease in fossil fuel reliance, while under the DES, that change is much more drastic (see Figure 2.2).

- Regionally, electricity currently has a relatively high share of the energy mix in rail passenger transport, although in road transport, there is still limited penetration of EVs. The share taken by electricity in road transport by 2050 therefore only increases from less than 1% today to around 4% under the PES. Under the DES, however, electricity accounts for around 45% of transport sector energy consumption by 2050. This is achieved via the mass adoption of electromobility in road vehicles for passengers – and to a lesser extent cargo vehicles – complemented by almost full electrification of rail.
- The use of renewable energy in transport is a remarkable feature of the region nowadays. This is due to the biofuel blending mandates for bioethanol and biodiesel and pure bioethanol used in flex vehicles. Penetration of these grows towards 2050 in both scenarios. Under the PES, the percentage of sector demand accounted for by biofuels increases from 13% in 2023 to 21% in 2050. Under the DES, the 2050 figure is 35%, due to a more ambitious use of biofuels primarily in road and air transportation.
- The share of transport sector energy consumption taken by fossil fuels declines in both scenarios. Under the PES, this share falls from 87% in 2023 (gasoline and diesel covering 82%, complemented by natural gas) to 74% in 2050. Under the DES, the share taken by fossil fuels falls to less than 20% over the same period, with this mainly consumed in road, air and domestic shipping

**Figure 2.2** Final energy consumption and $CO_2$ emissions in the transport sector under the PES and DES, 2023-2050




**Notes:** dir = direct; EJ = exajoules; $GtCO_2$ = gigatonne carbon dioxide; ind = indirect. Final consumption in transport refers to energy needs at the domestic level. Exports of hydrogen and its derivatives, and biofuels are presented in the corresponding chapters. The share of renewables includes direct and indirect (*e.g.* electricity generation) uses.

Under the PES, $CO_2$ emissions continue to increase over the 2023-2050 period, rising by almost 50% compared to the 2023 base year. The DES, however, cuts emissions by approximately 80% with respect to 2023 and over 85% compared to the 2050 level under the PES.

KPIs for the regional transport sector are presented in Table 2.1. In terms of cumulative investment in infrastructure and the acquisition costs of the sector over the period 2025-2050, the DES would require around USD 5 trillion – an amount 47% higher than under the PES. This is mostly due to the electrification of road fleet under the DES. Investment in charging infrastructure accounts for 3% in PES and 7% in DES of overall investment and costs, with this dominated by the deployment of EV charging stations.

**Table 2.1** Transport sector KPIs under the PES and DES, 2023-2050

| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **KPI.02 RENEWABLES (DIRECT USES)** | | | | | | | |
| Biofuels share in transport TFEC (%) | 13% | 17% | 20% | 21% | 18% | 26% | 35% |
| Direct and indirect renewable energy share in transport TFEC (%) | 13% | 18% | 21% | 24% | 19% | 41% | 80% |
| Biofuel-based vehicles stock (million units) | 30 | 44 | 65 | 89 | 44 | 50 | 49 |
| **KPI.03 ENERGY CONSERVATION AND EFFICIENCY** | | | | | | | |
| Total final energy consumption (EJ) | 6.9 | 8.2 | 10.2 | 12.0 | 8.1 | 7.6 | 6.4 |
| **KPI.04 ELECTRIFICATION IN END-USE SECTORS (DIRECT)** | | | | | | | |
| Share of electricity in transport TFEC (%) | 0% | 1% | 2% | 4% | 1% | 15% | 45% |
| Electric and plug-in hybrid passenger vehicles stock (million units) | 0 | 4 | 23 | 50 | 8 | 83 | 198 |
| EV chargers (million units) | 0 | 1 | 5 | 12 | 1 | 22 | 55 |
| **KPI.05 GREEN HYDROGEN AND DERIVATIVES** | | | | | | | |
| Clean hydrogen share in transport TFEC[1] | 0% | 0% | 0.5% | 0.9% | 0% | 0.4% | 0.6% |
| **EMISSIONS** | | | | | | | |
| $CO_2$ emissions with carbon capture and removal ($GtCO_2$/yr) | 0.42 | 0.48 | 0.55 | 0.62 | 0.46 | 0.31 | 0.09 |
| **TOTAL SYSTEM COSTS[2]** | | | | | | | |
| Cumulative - investment (2024 USD billion) | - | 2.2 | 15 | 77 | 3.6 | 64 | 285 |
| Cumulative - expenditure (2024 USD billion) | - | 585 | 1 191 | 1 571 | 603 | 1 639 | 2 449 |

Notes:

[1] *Clean hydrogen consumption refers to green and blue hydrogen.*

[2] *Total system costs per column refers to cumulative value per period, as follows: 2030 covers 2025-2030, 2040 includes 2031-2040, 2050 corresponds to 2041-2050.*

The higher shares of clean hydrogen under the PES are due to the energy plans of Argentina and Chile. The DES emphasises electrification in the long-term, leaving biofuels and fuel-cells to complete the sector's energy matrix; $CO_2$ = carbon dioxide; EJ = exajoules; EV = electric vehicles; Gt = gigatonnes; TFEC = total final energy consumption; yr = year.

In the following sections, a detailed perspective for decarbonisation of road, air, rail and water transportation in South America is presented, complemented by estimates of the level of investment required and the impact on emissions.

### 2.2.1 Road transport

Within the region, road transport – which includes passenger vehicles and cargo trucks – dominates the sector's energy consumption. In 2023, road transport accounted for 6.4 EJ, or around 95% of the sector's energy demand. This share was also characterised by a high dependency on fossil fuels, with these accounting for more than 85% of the total, followed by biofuels with over 10%. The latter were mainly produced domestically.

South America's road transport activity is also widely forecast to grow considerably over the next few years, mainly due to an increase in light vehicle ownership. In 2023, however, the motorisation rate – expressed in car ownership per 1 000 inhabitants – exhibited wide disparities around the region. Although the regional weighted average was around 160 vehicles, this number ranged between 30 and 300, depending on the location. Generally, however, national plans expect the motorisation rate to ramp up, given the expectations of higher household wealth. Over the study period, this should lead to a doubling of vehicle stocks. Similarly, road cargo transport continues expanding as a direct result of projected GDP growth, with the regional truck fleet expected to expand 70% between 2023 and 2050.

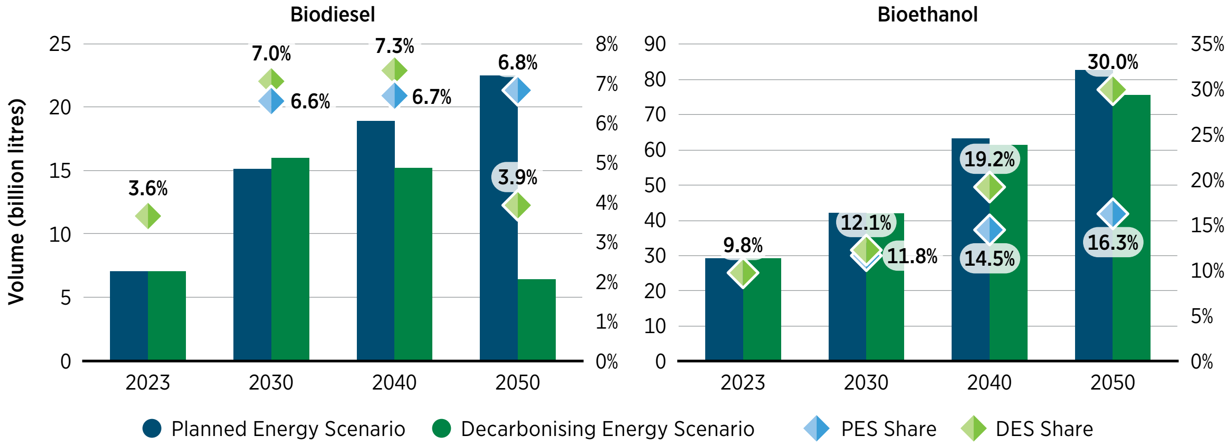
Historically, the region's road transport energy demand has been met by fossil fuels – mostly in the form of gasoline and diesel, although natural gas has also sometimes been used. In terms of vehicle type, light vehicles rely primarily on gasoline and diesel, with natural gas playing a role in Argentina and the Plurinational state of Bolivia. Heavy duty vehicles such as buses and trucks are largely powered by diesel. Several regional country energy plans note the important role of electromobility for decarbonisation, especially in light vehicles and buses. Other country plans see the transition as being complemented by an increased penetration of bioenergy and natural gas in road transport.

To promote a cleaner and more energy-efficient transport sector, several approaches have been taken within the region, with bioenergy seen as a major contributor. Brazil in particular stands out with its country-wide adoption of flex-fuel vehicles and high blending mandates. Argentina, Colombia and Paraguay also have ambitious biofuel mandates in place, with these expected to be expanded further. In countries with significant natural gas resources, such as Argentina and Bolivia, a natural gas-based fleet has also been successfully established, with these vehicles generally cheaper to run than those based on other fossil fuels. They also have a lesser environmental impact. Adoption of higher efficiency standards in all internal combustion engines (ICE) vehicles is also being promoted across the region, with targets matching ambitious international standards.

#### Biofuel blending

Blending mandates for bioethanol and biodiesel have helped boost the use of biofuels in transport around the region and particularly in road vehicles. Key countries such as Argentina, Brazil and Colombia have effectively implemented these mandates, setting blending levels within the 10%-27% of volume range for bioethanol and 15%-20% for biodiesel. In most cases these fuels are domestically produced, given the vast amount of biomass available for their production. In the PES, blending mandates both for bioethanol and biodiesel are expected to reach higher levels in several regional countries, with technical limits of 27% and 25%, volume per volume, for bioethanol and biodiesel, respectively. For the period 2023-2050, Figure 2.3 presents the projected volumes of biodiesel and bioethanol under the PES and DES and their respective shares in road transport's TFEC.

**Figure 2.3** Biodiesel and bioethanol consumption (billion litres) and shares in road transport TFEC (%) under the PES and DES, 2023-2050

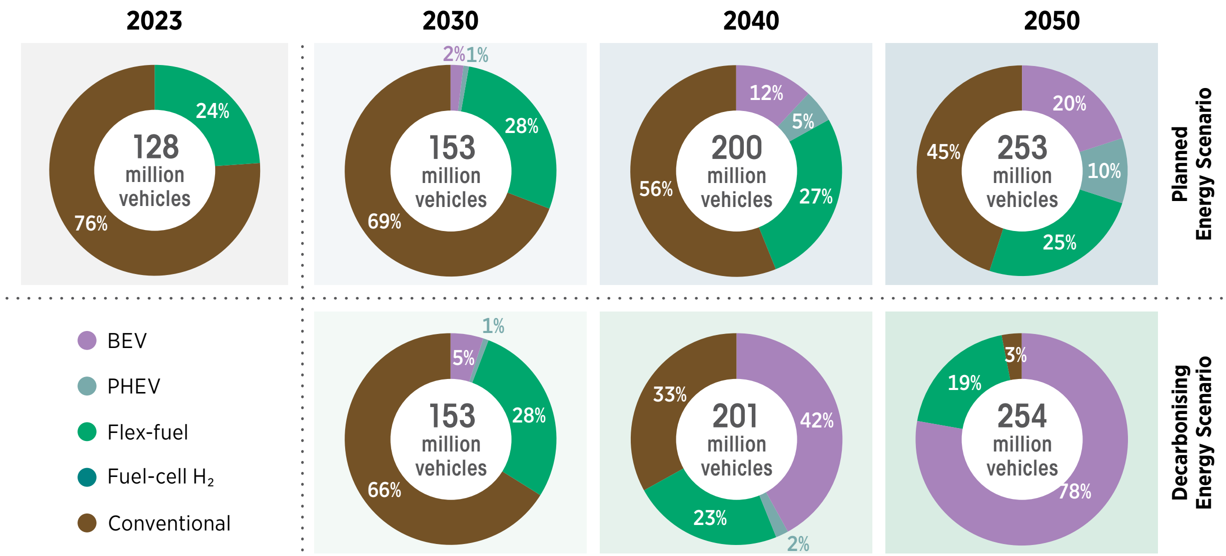



## Road transport technology

The DES envisages a hybrid approach in which both electrification and bioenergy are targeted. Following the successful Brazilian precedent, in the short and medium term, the adoption of flex fuel technology in light vehicles is expanded in key countries such as Argentina, Colombia and Paraguay. Furthermore, as this decade will see upfront prices of EVs in major economies reach parity with ICE vehicles (BNEF, 2024a), electromobility dominates in the long term across all South American countries and types of vehicles, with a major scaling up in electric light vehicles, two and three wheelers and buses.

At the same time, under the DES the road cargo fleet also sees a drastic transformation. This occurs as fossil fuel-based fleets shift to a variety of new energy sources. These include: battery EVs (BEVs), with more medium and small-sized trucks using these; bioenergy, such as fuel cell bioethanol (a novel technology in Brazil); hydrogen in countries currently considering this technology; and natural gas in compressed or liquefied form as a transitional measure. Figure 2.4 provides an overview of the technologies adopted and their fleet shares under the PES and DES across the study period.

**Figure 2.4** Road transport vehicle fleet composition (million vehicles) under the PES and DES, by technology, 2023-2050




**Notes:** BEV = battery electric vehicles;PHEV = plug-in hybrid vehicle; fuel-cell $H_2$ = fuel cell hydrogen. "Conventional" refers to ICE fuelled by gasoline, diesel, natural gas and liquefied petroleum gas (LPG).

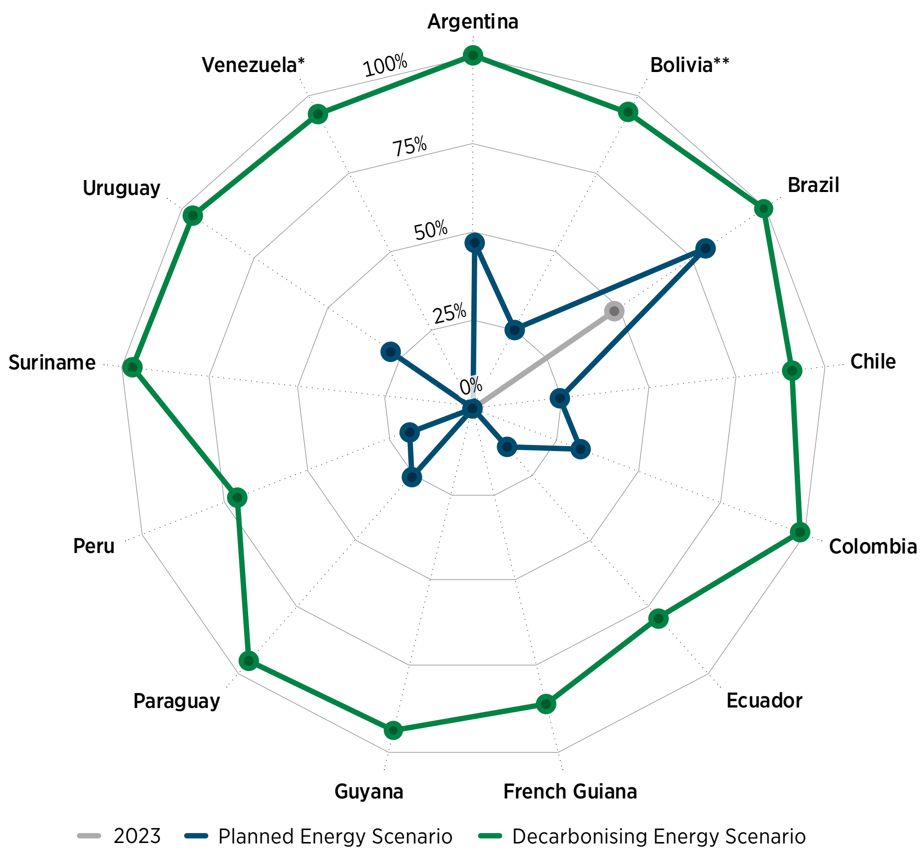
Energy consumption by subsector, passengers and cargo would undergo distinctive transitions. In the case of road passengers' fleet, higher decarbonisation is achieved through electrification and bioenergy penetration – both economically and technically feasible – transforming almost the entire fleet by 2050. In road cargo a shift towards electrification is envisaged to be dominant, since the role of bioenergy is more restricted, lower biodiesel blending compared to bioethanol, and fuel cell bioethanol in long-haul trucks is only anticipated to play a role in niche markets.

The adoption by each country's road fleet of cleaner technologies (*e.g.* flex-fuel vehicles, electric and hydrogen-based vehicles) is presented in Figure 2.5. In 2023, Brazil was the regional leader in terms of low-emissions passenger vehicles, given the high penetration in that country of flex-fuel technology. The other countries of the region had lower shares, mainly less than 1% and mostly accounted for by EVs.

Under the PES, the region aims for a moderate decarbonisation, with electrification increasing significantly in Argentina, Chile, Colombia and Uruguay, complemented by flex-fuel vehicles in Argentina and Paraguay. Under the DES, clean technology deployment is scaled up across the region. Chile and Uruguay, for example, mainly target electrification, while others (*e.g.* Argentina, Brazil and Colombia) adopt a hybrid strategy of electric and flex-fuel vehicles.

With respect to the road cargo fleet, up to 2050, electrification and the use of hydrogen are fostered under the PES, notably in Chile and Uruguay. The DES exhibits a higher electrification penetration rate in small and medium-sized fleets, complemented by the introduction of fuel cell bioethanol vehicles in Brazil – a novel technology deployed in medium-sized and heavy-duty trucks.

**Figure 2.5** South America's clean transport vehicles share in total road fleet (%) in 2023, and under the PES and DES by 2050, by country



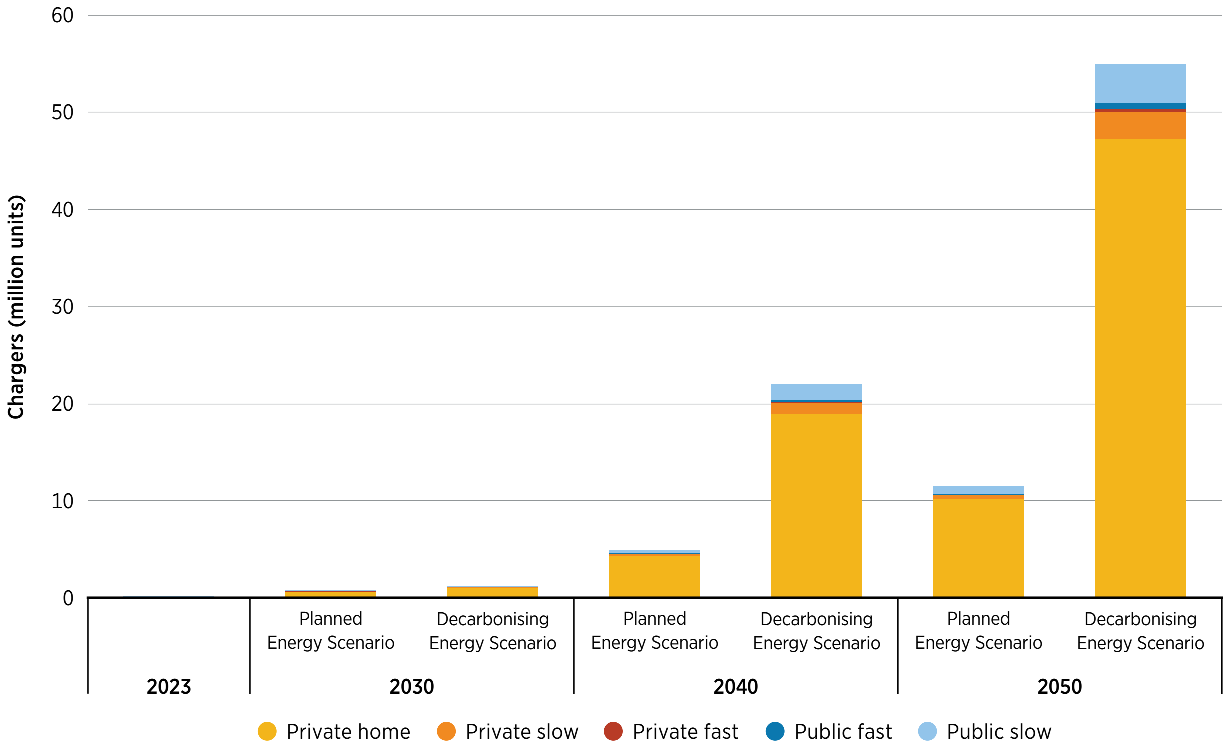

**Notes:** Clean technologies in transport include BEV, PHEV, flex-fuel and fuel cell hydrogen; * The Bolivarian Republic of Venezuela; ** The Plurinational State of Bolivia

**Infrastructure requirements for road transport**

The widespread adoption of EVs in the region requires infrastructure installation for each type of user. The current assessment divides charging stations into two groups: public and private, each of them further divided into "fast" and "slow", with an additional category of home chargers for residential users.

The EV stock projections under the PES require the rapid deployment of chargers, with these reaching around 12 million units by 2050. Private home chargers would account for 89% of these, with public chargers accounting for 8%, and the remaining share corresponding to depot chargers (see Figure 2.6). Under the DES, electromobility becomes the dominant technology in the long-term, requiring an even greater deployment of charging points. Indeed, five times as many as under the PES would need to be deployed by 2050. This translates into approximately 55 million units, of which around 85% would be private home chargers.

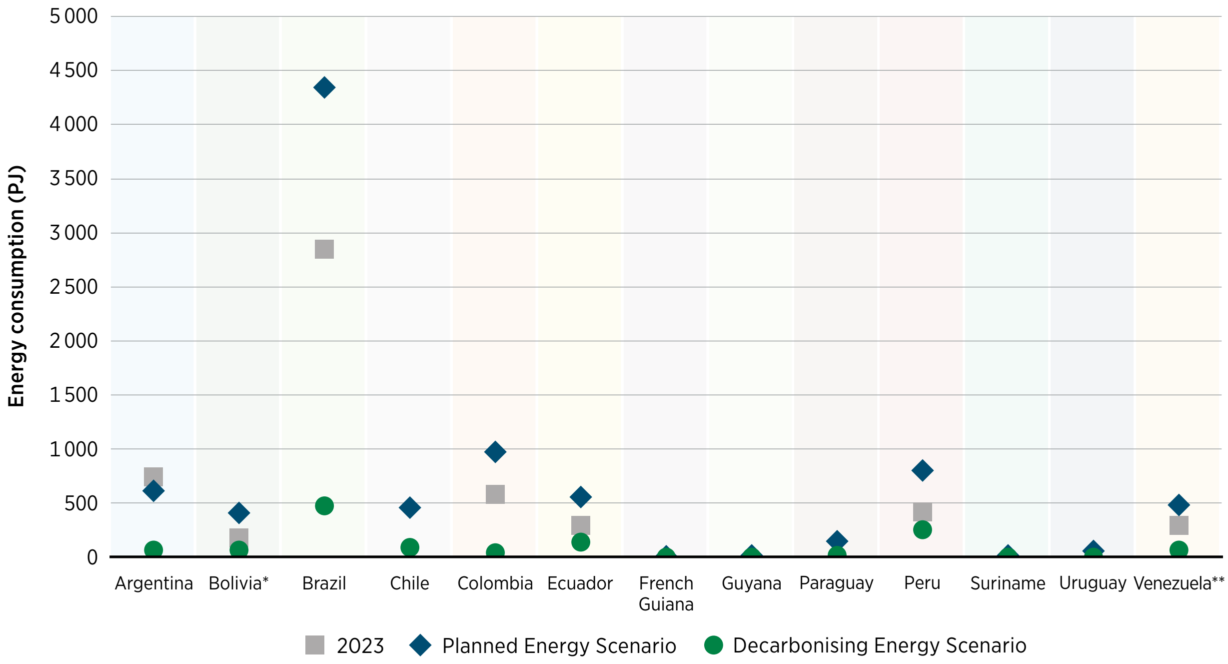
**Figure 2.6** Electric charging points (million units) under the PES and DES, by type, 2023-2050




Notes : Private home chargers are typically 7 kilowatt (kW) to 22 kW for motorcycles, cars and sports utility vehicles (SUVs); public slow and fast chargers refer are typically 7 kW to 22 kW (slow) and above 50 kW (fast) for light vehicle and bus charging. Private slow and fast chargers include depot chargers for buses and trucks (22 kW to 50 kW slow, 150 kW to 350 kW fast), and fast chargers (150 kW to 350 kW).

In addition to the mass deployment of charging infrastructure, in both scenarios the sector's need for oil products (*i.e.* diesel and gasoline) should also be properly assessed. As can be seen in Figure 2.7, South American's transport sector demand for fossil fuels remains at a similar level over time, albeit with a slight increase under the PES (except for Brazil). In the DES, however, there is a drastic reduction in all countries due to the deployment of cleaner technologies, dominated by electrification and the use of biofuels.

**Figure 2.7** South America's fossil fuel consumption in the transport sector (PJ) in 2023, and under the PES and DES by 2050, by country




**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela; PJ = petajoules.

### 2.2.2 Aviation

South America's domestic air transport sub-sector has grown in recent years, particularly in those countries with large land areas and considerable distances between their population centres. At the same time, aviation has become progressively more affordable for internal transportation. In alignment with the expected growth of the region's economies and global market developments, air transport activity is also projected to double between 2023 and 2050.

According to the energy balances of the region's countries, the TFEC of South America's air transport sector was 260 petajoules (PJ) in 2023. Aircraft fleets were entirely fuelled by fossil fuels, with these meeting approximately 4% of overall transport sector energy demand. Together, Argentina, Brazil, Colombia and Chile accounted for around 85% of total regional aviation energy demand.

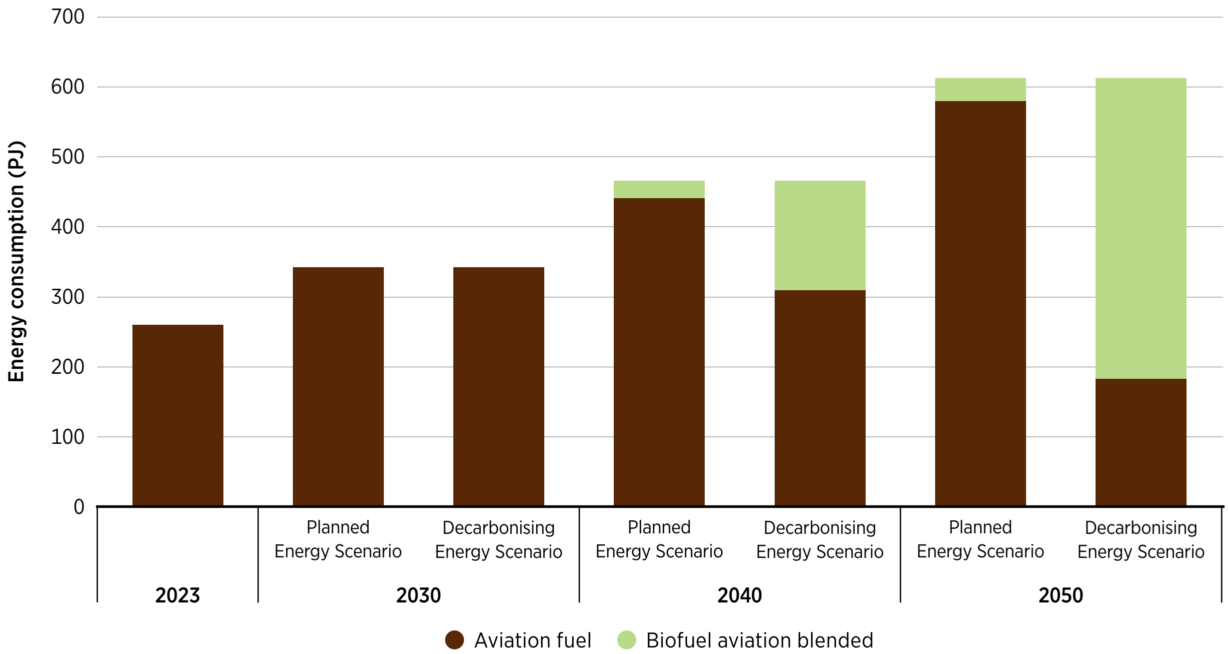
With aviation passenger activity expected to more than double over the 2023-2050 period, the need for measures to help decarbonise the sector is clear. These steps should align with the international targets already under discussion by the sector's main stakeholders. The International Civil Aviation Organization (ICAO) has established a global aspirational goal of achieving net-zero carbon emissions for international aviation by 2050. This target is heavily dependent on new technologies, operational improvements and a massive scale-up in SAF production and use. Achieving this goal demands an unprecedented effort, including an estimated USD 3.2 trillion of global investment in cleaner aviation fuel production alone by mid-century (ICAO, 2024).

In both the PES and DES, the aviation sector's energy consumption is expected to more than double over the period, reaching over 600 PJ by 2050 (see Figure 2.8). In terms of the energy mix, the biojet fuel volumes required to gradually decarbonise regional air transport increase in ambition between the PES and the DES. In the PES, a small amount of biojet fuel is introduced, as only Brazil has committed to a biojet blending mandate, starting in 2032.[17] Biojet's share of the aviation sector's TFEC reaches 5% in 2050, or around 950 million litres under this scenario. Under the DES, however, biojet blending is expected to reach almost two-thirds of total aviation sector fuel volume by 2050 – a level in alignment with international aviation targets (IATA, 2025a). This translates into biojet taking a 70% share of aviation's energy demand in 2050, an amount equal to more than 12 billion litres of fuel.

With respect to emissions, aviation contributed to around 4% of the transport sector total in 2023. Under the PES, this share grows to almost 7% by 2050. Under the DES, emissions are cut around 70% by 2050 compared to the PES, and 30% compared to the 2023 base year.

With its extensive land area, South America could potentially contribute significant SAF feedstocks by using degraded or abandoned farmland. It would do this in accordance with ICAO sustainability criteria, further supported by updated methodologies that better reflect tropical and subtropical land-use dynamics, as well as the recent ICAO technical recommendation endorsing the type of multiple cropping common in the tropics (MRE, 2025). Exports to regions with existing SAF mandates, like Europe, may occur in the early stages, before full domestic adoption in South America. Such a development could serve as a catalyst for investment and ecosystem development. Realising this potential, however, requires a major scale-up in production and investment. Massachusetts Institution of Technology (MIT) research conducted in 2025 estimated at least USD 204 billion in investment was needed for SAF facilities in five selected South American countries plus Mexico by 2050, alongside modern logistics and certification systems to meet international standards (Dwortzan, 2025).

**Figure 2.8** Final energy consumption in the aviation sector under the PES and DES, by energy type, 2023-2050




**Notes:** This figure refers to domestic consumption. Alternative fuels for international aviation bunkering are presented in the section on and maritime biofuels below; PJ = petajoule.

[17] *Measures modelled in PES include only Brazil as it is a country mandate approved by the government, in addition to the availability of information by the time of analysis.*

### 2.2.3 Rail transport

Rail transport for goods and passengers is the most energy-efficient means of land transportation. It is also widely used across some of the most densely populated areas of South America, both above ground and underground, using diesel or electric locomotives. Rail freight is predominantly diesel powered, with its role in terms of the overall transport of goods varying between regional countries.

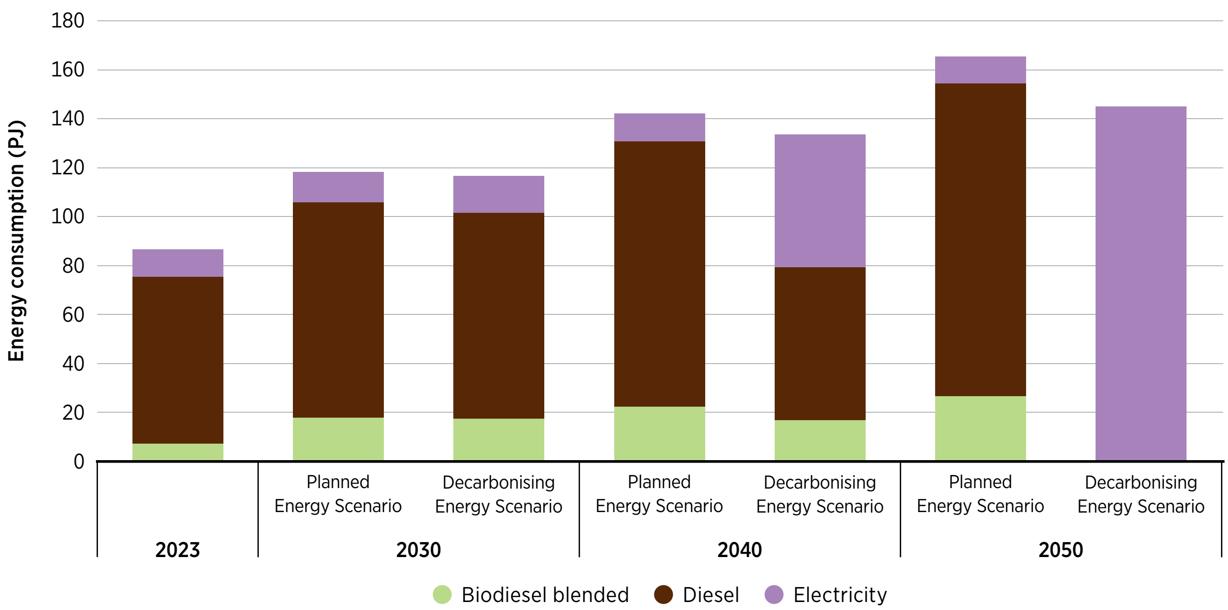
In terms of railway energy consumption, in 2023, this totalled 87 PJ, with fossil fuels – mainly used in freight transportation – covering 78% of that. Electricity, the main energy source for passenger transportation, contributed 13%, while biodiesel blending had a share of around 9%. That year, Brazil was the top consumer, with a share of more than 85% of the South American rail freight energy consumption.

As avenues to decarbonisation, most countries in the region are currently promoting increased electrification of the rail passenger service, while the use of natural gas and partial electrification are under consideration for freight.

In the region, activity in both passenger and freight traffic is projected to increase out to 2050 – the former by 1.5-times while the latter will double over the period. A transition towards cleaner rail transport would entail greater electrification and use of bioenergy, with differentiated penetration rates for passengers and cargo. Regarding passenger transport, a complete electrification of urban and regional railway networks could be achieved first, given this mode's more favourable access to financing and its benefits in terms of reduced pollution. This could gradually expand to include more intra-regional and inter-regional networks. For freight, decarbonisation is expected to be more challenging in the short term, considering the distances that have to be covered by new or upgraded infrastructure. This means achieving a lower electrification rate from freight than for passengers, with more bioenergy use helping make up the difference.

Under the PES, rail transportation's energy demand almost doubles during the study period, reaching 165 PJ by 2050. Biodiesel accounts for 16% of this (see Figure 2.9). In contrast, under the DES there is a complete electrification of passenger and cargo rail transportation by 2050, with an estimated TFEC of 145 PJ.

**Figure 2.9** Final energy consumption in rail transport under the PES and DES, by energy type, 2023-2050




**Note:** PJ = petajoules.

## 2.2.4 Shipping

South America's domestic water transportation network, which carries both people and goods on navigable waterways such as rivers, canals and lakes, is relied upon heavily in Argentina, Brazil and Colombia. Movement of goods by waterway across long distances can also be the most efficient means of transportation, with energy requirements per tonne per kilometre notably lower than road and rail.

In terms of energy consumption, this mode is largely dominated by freight, with the transport of passengers playing a minor role, either for tourism purposes or to connect dispersed populations. As of 2023, domestic shipping accounted to around 60 PJ, completely powered by liquid fossil fuels.

For transportation along internal waterways and for domestic shipping, conservative long-term electrification rates apply under the scenarios.[18] In 2050, under the PES, energy consumption for this mode is estimated at around 250 PJ, while under the DES, the figure is approximately 230 PJ.[19]

[18] *Biofuels could also be considered a decarbonisation alternative in the form of blending into fuel oil (the main energy type in domestic shipping). Current modelling considers the blending of biofuels into diesel or gasoline only.*

[19] *This refers to domestic consumption. Alternative fuels for international bunkering in shipping are presented in the sections below entitled "Aviation and maritime biofuels" and "Expansion of hydrogen production and trade".*

## 2.3 POLICIES FOR TRANSPORT SECTOR TRANSFORMATION

### 2.3.1 Road transport

Globally, investments in electrified transport have increased by more than five times in 2015-2024, with electric vehicles (EVs) accounting for 18% of global car sales in 2023 (IEA, 2024b, 2025a). Although South America has been slower to embrace this shift, important progress is underway. In 2024 alone, almost 300 000 electric and hybrid vehicles were sold across the region, signalling growing momentum (ANDEMOS, 2024). Table 2.2 summarises the key policy measures promoting transport decarbonisation in South America.

**Table 2.2** Main incentives for promoting road transport decarbonisation in South America

| COUNTRY | INCENTIVES FOR PROMOTING TRANSPORT DECARBONISATION |
|---|---|
| **Argentina** | 2025: Import tariffs lifted on some low-cost electric and hybrid vehicles. Up to 50 000 imported low-cost EVs and hybrids will be exempt from tariffs for one year.<br>2024: The Sustainable Mobility Programme (*Programa de Movilidad Sustentable*) promotes micro-mobility and low-emissions transport for individuals and businesses, supports compressed natural gas (CNG) and electric mobility, and provides financial incentives for vehicle and infrastructure investments. |
| | 2023: Bill on the Promotion of Domestic Production of Electric and Hybrid Vehicles.[20] |
| | 2023: Electric bus deployment – 2023 government spending.[21] |
| **Brazil** | 2024: The Green Mobility and Innovation Programme (*Programa de Mobilidade Verde e Inovação* [Mover]) aims to support local manufacturing of EVs by granting tax incentives to companies producing automotive items, strategic solutions for mobility and logistics, and the use of raw materials and components for these vehicles.<br>2024: Law No. 14 993 – the Fuel of the Future Law (*Lei dos Combustíveis do Futuro*) created the SAF Programme (*Programa Nacional de Combustível Sustentável de Aviação* [ProBioQAV]), the Green Diesel Programme (*Programa Nacional de Diesel Verde* [PNDV]), and the Natural Gas Decarbonisation Programme (*Programa de Descarbonização do Produtor e Importador de Gás Natural e de Incentivo ao Biometano* [PNDG]), which promote the production and use of SAF, green diesel and biomethane.<br>2024: Programme providing financial support for urban public transport systems and urban mobility enhancement.<br>2023: Resolution No. 3/2023 on the evolution of the mandatory addition of biodiesel to diesel oil sold to the final consumer,[22] updated by Resolutions No. 8/2025 and No. 9/2025 with mandatory addition of anhydrous ethanol to gasoline. |
| | 2023: EV import tariffs and quotas.[23] |
| | 2023: EV import tariff inflexion.[24] |

[20] For details see the IEA web page, www.iea.org/policies/20266-bill-on-the-promotion-of-domestic-production-of-electric-and-hybrid-vehicles (accessed 15 October 2025).

[21] For details, see www.iea.org/policies/20271-electric-bus-deployment-2023-government-spending (accessed 15 October 2025).

[22] For details, see www.iea.org/policies/20501-resolution-no-32023-on-the-evolution-of-the-mandatory-addition-of-biodiesel-to-diesel-oil-sold-to-the-final-consumer (accessed 15 October 2025).

[23] For details, see www.iea.org/policies/18449-electric-vehicle-import-tariff-and-quotas (accessed 15 October 2025).

[24] For details, see www.iea.org/policies/20263-electric-vehicle-import-tariff-inflexion (accessed 15 October 2025).

| Country | Policies |
|---|---|
| Plurinational State of Bolivia | 2021: Import duty and tax reductions for electric and hybrid vehicles.[25] |
| Colombia | 2024: Announcement of the creation of the Technological Advancement Fund. In Colombian pesos (COP), this was backed by COP 12 billion its first year of operation, which will cover the price difference between a petrol vehicle (COP 80 million) and a zero-emissions vehicle (approximately COP 110 million).<br>2022: Resolution 40447 of 2022, which establishes the maximum content of a mixture of fuel alcohol.[26]<br>2019: EV import tariff exemption.[27]<br>2019: Minimum EV purchase quota of 30% for public service fleets by 2025, while minimum EV charging infrastructure requirements specified a minimum of five charging stations in all Special Category municipalities and 20 stations in Bogotá by 2022.<br>2019: A national minimum share of 30% for EVs among new public buses purchased or rented by 2025, while city bus fleets had to ensure that 10% of new buses were EVs in 2025, rising every two years to 100% by 2035.<br>2019: Law 1972 of 2019 required 100% compliance with Euro-VI equivalent standards for all heavy duty vehicles in circulation by 2035. |
| Ecuador | 2021: Low- and zero-emission vehicles exempted from VAT. They are also exempt from import taxes, along with charging equipment.<br>2021: National Electromobility Strategy.[28]<br>2019: Import duty elimination for EVs and charging infrastructure equipment.[29]<br>2019: 100% of new public transport fleet to be electric by 2025. |
| Chile | 2023: Chile's Ministry of Transport and Telecommunications allocated financial support through the Urban Road and Transportation Programme (Programa de Vialidad y Transporte Urbano de la Subsecretaría de Transportes) to projects in rail services, mass transit, walkways and bike lanes.<br>2022: My Electric Taxi Programme - Electrification of Valparaíso taxi fleet.[30]<br>2021: National Electromobility Strategy.[31]<br>2021: Accelerated tax depreciation of electric, hybrid and zero-emissions vehicles.<br>2021: Energy efficiency law promotes the importation of BEVs and PHEVs. Entered into force in 2024, requiring fleet average efficiency of 5.3 litres of gasoline equivalent (LGE) per 100 km for the period 2024-2026. For 2027-2029, an improved target of 22.8 km/LGE was set, with 2030 seeing a further increase, to 28.9 km/LGE.<br>2020: "Move without leaving a footprint" programme (credit for EV acquisition).[32] |

[25] *For details, see www.iea.org/policies/20081-import-duty-and-tax-reductions-for-electric-and-hybrid-vehicles (accessed 15 October 2025).*

[26] *For details, see www.iea.org/policies/20503-resolution-40447-of-2022-on-which-establishes-the-maximum-content-of-a-mixture-of-fuel-alcohol (accessed 15 October 2025).*

[27] *For details, see www.iea.org/policies/20304-electric-vehicle-import-tariff-exemption (accessed 15 October 2025).*

[28] *For details, see www.iea.org/policies/19924-electromobility-national-strategy (accessed 15 October 2025).*

[29] *For details, see www.iea.org/policies/20083-import-duty-elimination-for-electric-vehicles-and-charging-infrastructure-equipment (accessed 15 October 2025).*

[30] *For details, see www.iea.org/policies/14853-my-electric-taxi-program-electrification-of-valparaiso-taxi-fleet (accessed 15 October 2025).*

[31] *For details, see www.iea.org/policies/14381-national-electromobility-strategy (accessed 15 October 2025).*

[32] *For details, see www.iea.org/policies/12982-move-without-leaving-a-footprint-program (accessed 15 October 2025).*

| | |
|---|---|
| **Uruguay** | 2025: National Policy on Sustainable Urban Mobility.[33]<br>2024: Import duty inflexion on EVs.[34]<br>2022: Decree 441/021 – Uruguay $CO_2$ tax.[35]<br>2020 - Electric Vehicle Import Incentives (Decree No. 268/023).[36] |
| **Peru** | 2022: Enhancement of NGV conversion programme.[37] |
| **Paraguay** | 2012: Import duty exemption for electric and hybrid vehicles.[38] |

**Source:** (IEA, 2023a, n.d.a).

Brazil, the region's largest economy, has recently seen BEV, PHEV and hybrid electric vehicle (HEV) registrations increase year-on-year, with 2024 seeing a total of more than 177 000. This represented a share of 7% of total vehicle registrations that year (Fenabrave, n.d.). While Brazil continues to prioritise biofuels such as biodiesel and ethanol as its main strategy for decarbonising road transport, electromobility is also expanding without direct government incentives. Electrified buses are expected to represent 9% of Brazil's fleet by 2034, with several bus rapid transit systems transitioning to electric models (Ministério de Minas e Energia, 2024).

Meanwhile, Chile, Colombia and Uruguay have developed comprehensive electromobility policies, while the Plurinational State of Bolivia, Ecuador, Paraguay and Peru are also establishing low-emissions transport strategies. Cities like Bogotá and Santiago have rolled out large fleets of electric buses, providing cleaner and more affordable mass transit. Chile's electromobility strategy aims to electrify 100% of its urban public transport fleet by 2050, supported by a ban on ICE car sales by 2035, although to date, private EV adoption remains modest.

Colombia has also emerged as a regional leader in electromobility, combining regulatory reforms and financial incentives to accelerate zero-emissions transport. Policies such as its sustainable mobility law, generous tax exemptions for EVs and mandates for public transport electrification have strengthened market uptake. By 2035, all new public transport vehicles in Colombia's major cities must be electric, with fast-charging infrastructure targets complementing vehicle deployment. Bogotá has been particularly active, registering higher EV sales than many larger economies in the region.

[33] *For details, see www.gub.uy/ministerio-ambiente/politicas-y-gestion/politica-nacional-movilidad-urbana-sostenible (accessed 15 October 2025).*

[34] *For details, see www.iea.org/policies/20085-import-duty-inflexion-on-electric-vehicles (accessed 15 October 2025).*

[35] *For details, see www.iea.org/policies/19297-decree-441021-uruguay-co2-tax (accessed 15 October 2025).*

[36] *For details, see www.iea.org/policies/19948-electric-vehicle-import-incentives-decree-no-268023 (accessed 15 October 2025).*

[37] *For details, see www.iea.org/policies/16861-enhancement-of-ngv-conversion-programme (accessed 15 October 2025).*

[38] *For details, see www.iea.org/policies/20084-import-duty-exemption-for-electric-and-hybrid-vehicles (accessed 15 October 2025).*

Uruguay, leveraging its near 100% renewable electricity generation, has also positioned itself at the forefront of transport electrification. The country has launched Latin America's first electric highway, with charging points spaced every 50 km. Uruguay also offers a wide range of fiscal incentives for EVs and is rapidly expanding its electric fleets across public and private transport. Targets have been set for 50% of the bus fleet to be electric by 2030 and 100% by 2040 (AméricaEconomíca, 2025). Uruguay's leadership in clean energy and transport innovation has also made it a strategic entry point for international automakers.

Despite this growing momentum, however, challenges persist. High upfront costs, the limited charging infrastructure in some countries and competition from biofuel industries continue to temper the pace of electrification. Yet, with increasing sales, supportive policies and abundant clean energy resources, South America's transport sector is clearly advancing toward a more sustainable, low-carbon future.

### 2.3.2 Aviation

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is the first global market-based strategy that applies to a transport sector. To meet the ICAO's aspirational goal of carbon neutral growth, CORSIA complements other in-sector aviation emissions reductions efforts, such as technological innovation, operational improvement and SAF development (ICAO, n.d.a). In South America, Ecuador, Guyana, Uruguay and Suriname will participate voluntarily in CORSIA in 2026 (ICAO, n.d.b).

Three countries stand out for their dedicated SAF targets and road maps. The first is Chile, which aims to achieve 50% SAF use in aviation by 2050, with the promotion of local biofuel and green hydrogen production (Ministerio de Energía, 2024). Brazil's Fuel of Future Law mandates a 1% annual emissions reduction from 2027, while Colombia has set a production target of 100 million gallons of SAF by 2035 and 450 million gallons by 2050 (Gomez, 2025). To produce SAF economically, it is necessary to do so at scale, with hydrotreated esters and fatty acids the most promising route in South America due to its lower capital and operational expenditures. Regional co-operation on SAF can also help achieve competitive costs.

### 2.3.3 Rail

Brazil's National Railway Plan aims to boost this mode's share of total freight transport from around 17.7% to 34.6%. This is to be done by focusing on sustainable infrastructure, governance reforms and investment mechanisms. One key goal is a major east–west corridor that could reduce $CO_2$ emissions by up to 65 million tonnes over 50 years by shifting freight from roads to rail (UIC, 2023).

In Colombia, the Eastern Regional Tram (Regiotram de Occidente) is a tram-train project slated for electric operation. When completed, it will link Bogotá with surrounding cities using modern, low-emission trains and is expected to enter service in 2026.

### 2.3.4 Shipping

In March 2025, Brazil and Norway signed a memorandum of understanding to establish a transatlantic green shipping corridor, advancing the use of low- and zero-carbon fuels and sustainable maritime transport between them. Brazil's federal cabotage law also incentivises coastal shipping over road transport, aiming to grow fleet capacity while reducing logistics emissions. Chile also supports binding International Maritime Organisation (IMO) maritime fuel/GHG standards and carbon pricing mechanisms. Argentina, Peru and Colombia are also engaging in shipping decarbonisation via regional forums.

# 03

# ENERGY TRANSITION PATHWAYS: **INDUSTRY**

## INSIGHTS AND RECOMMENDATIONS FOR THE ENERGY TRANSITION IN INDUSTRY

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ Industrial energy demand in South America is projected to grow by about 2% annually under the PES. Achieving deep decarbonisation will require a combination of renewable deployment, electrification, energy efficiency improvements, circular economy measures, and carbon capture technologies. Under the DES, emissions could fall by 70% by 2050 compared to current plans. | ★ Develop comprehensive sectoral decarbonisation roadmaps for energy-intensive industries with clear targets and milestones. Introduce carbon limits, emission quotas, and green product standards to stimulate market demand for low-carbon and sustainable industrial materials. |
| ★ Brazil, Argentina and Colombia account for nearly three-quarters of South America's industrial energy use and are among the region's major producers of iron, steel and alumina. Decarbonisation offers an opportunity to enhance value-added production, strengthen industrial competitiveness, and position the region as a global leader in green materials. | ★ Provide fiscal incentives for low-carbon technologies, tax credits for avoided emissions, and promote public procurement of green products. Establish investment platforms and public-private partnerships to attract private and international finance for industrial decarbonisation. |
| ★ Renewables (direct and indirect uses) could supply up to 78% of industrial energy demand under the DES by 2050, led by bioenergy (46%) and clean hydrogen (2%). | ★ Set renewable energy targets for industry and simplify permitting procedures. Expand grid capacity and flexibility and introduce tax incentives to encourage renewable energy use by industrial consumers. |
| ★ Electricity's share of industrial energy demand is projected to rise from 19% in 2023 to 30% by 2050 under the DES, driven by electrification and energy efficiency improvements. | ★ Promote energy efficiency through standards, labelling, and mandatory investment obligations. Accelerate industrial digitalisation to strengthen monitoring, reporting and verification of decarbonisation progress. |
| ★ Circular economy practices can significantly reduce demand for primary materials. By 2050, scrap-based (electric-arc) steel could reach 28% of total regional production, recycled paper 53%, and recycled aluminium 50% under the DES. | ★ Encourage circularity through fiscal incentives for scrap use, import tax exemptions, and procurement of low-carbon and recycled products. Support reverse logistics, design for reuse, and sustainability certification schemes to close material loops. |
| ★ Carbon capture and storage (CCS) and bioenergy with carbon capture and storage (BECCS) will play a key role in addressing residual emissions in hard-to-abate sectors. Retrofits of industrial facilities could offset over 800 $MtCO_2$ by 2050 under the DES. | ★ Develop CCS roadmaps, support R&D and pilot projects, and invest in $CO_2$ transport and storage infrastructure to enable large-scale deployment. |
| ★ Cumulative investments in industrial decarbonisation are estimated at around USD 223 billion under the DES over the 2025-2050 period, averaging USD 8.9 billion/year. | ★ Mobilise blended finance through national development banks and regional investment platforms. Incorporate real-time industry feedback to adjust and refine policies, improve regulatory frameworks and ensure effective implementation. |

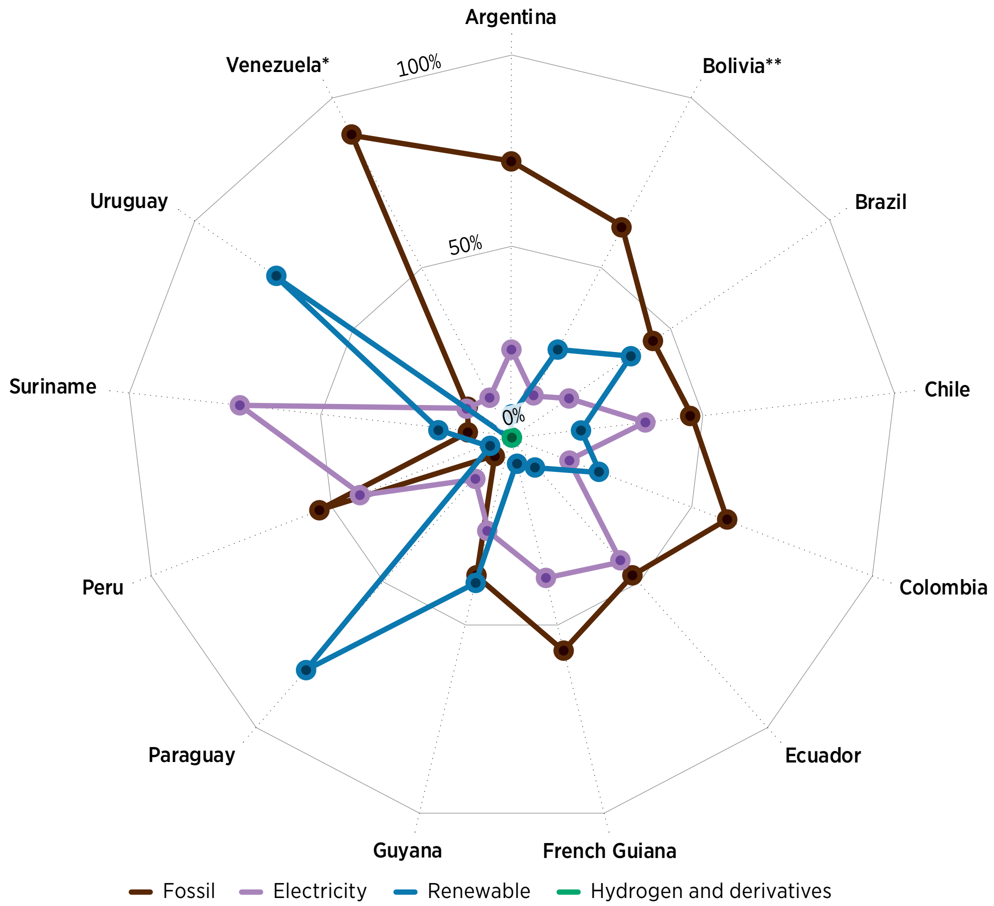
## 3.1 OVERVIEW OF THE INDUSTRY SECTOR IN THE REGION TODAY

In 2023, industry accounted for 7.5 EJ (more than one-third) of the region's end-use sector energy demand. Moreover, industry's production processes are carbon intensive, making the sector responsible for one-third of South America's total $CO_2$ energy-related emissions that same year. This was the second-highest emissions level after the transport sector.

In terms of subsectors, South America is a more industrialised region than other areas of Latin America, such as Central America and the Caribbean. Key countries such as Brazil, Argentina and Colombia have significant energy-intensive industries. These include: iron and steel, which also exports raw materials such as iron ore, pig iron and sponge iron; pulp and paper production that also have high rates of recycling in the value chain; cement and clinker production; and aluminium, which exports large quantities of its raw materials, bauxite and alumina. In 2023, these three countries together accounted for around 75% of the region's total industrial final consumption. Brazil accounted for 62% of this, followed by Argentina with 9% and Colombia with 4.4%.

Most of the energy used by the region's industry is currently sourced from fossil fuels. In 2023, these accounted for 53% of the sector's final consumption (including energy and non-energy uses[39]), with bioenergy accounting for 28% and electricity 19%. Figure 3.1 shows the energy mix of the industrial sector, by country, for the same year.

**Figure 3.1** South America's final energy consumption of the industrial sector, by country, 2023




**Note:** * The Bolivarian Republic of Venezuela; ** The Plurinational State of Bolivia.

[39] *Non-energy uses include coke ovens, blast furnaces, chemical fuels and feedstocks, along with industry co-generation.*

At the country, regional and international levels, there are a number of associations, chambers and committees that currently contribute to the development of South American industry. These working groups and entities serve not only as knowledge and statistics hubs, but also as platforms for the development of decarbonisation roadmaps. They also foster research and the implementation of innovative technologies – mainly in renewables – to aid in the exploitation of the region's resource potential and to boost the competitiveness of the region's markets.

Examples of these international and regional associations include the Latin American Steel Association (*Asociación Latinoamericana del Acero* [ALACERO]), which is linked to the World Steel Association; the Latin American Cement Federation (*Federación Interamericana del Cemento*); and the International Aluminium Institute (IAI). At a country level, there are organisations such as the Brazilian Steel Institute (*Instituto Aço Brasil*), the Brazilian Aluminium Association (*Associação Brasileira do Alumínio* [ABAL]), the Argentinian Chamber of Steel (*Cámara Argentina del Acero*), the Argentinian Chamber of Aluminium and Related Metals (*Cámara Argentina de la Industria del Aluminio y Metales Afines*), among others. Studies and statistics from these bodies, complemented by material published by private sector stakeholders and related insights in the energy plans of individual countries, served as detailed inputs in the modelling presented here.

The South American industrial sector is expected to continue its rapid economic development in the years ahead. According to the energy plans consulted in this analysis, the sector will see energy demand grow by approximately 2%/year over the study period. This requires a portfolio of measures to tackle decarbonisation in the sector's hard-to-abate subsectors. These measures can also add value to their products, however.

The following sections of this chapter address two crucial questions related to regional industry:

- What avenues of technology are key to tackling current and future emissions in ever-growing South American industries?
- What are the benefits and opportunities for national industrial production and the international market that the energy transition presents?

## 3.2 TRANSITION ROADMAPS FOR THE INDUSTRY SECTOR

By 2050, under the PES, final consumption by the region's industrial sector (both energy and non-energy) is expected to reach 12 EJ. Under the DES, a portfolio of measures for the decarbonisation of the region's industrial sector is proposed. This takes into consideration current country contexts and the great potential South America has for renewable energy, allowing production value-added to be raised and a restructuring of manufacturing across the region.

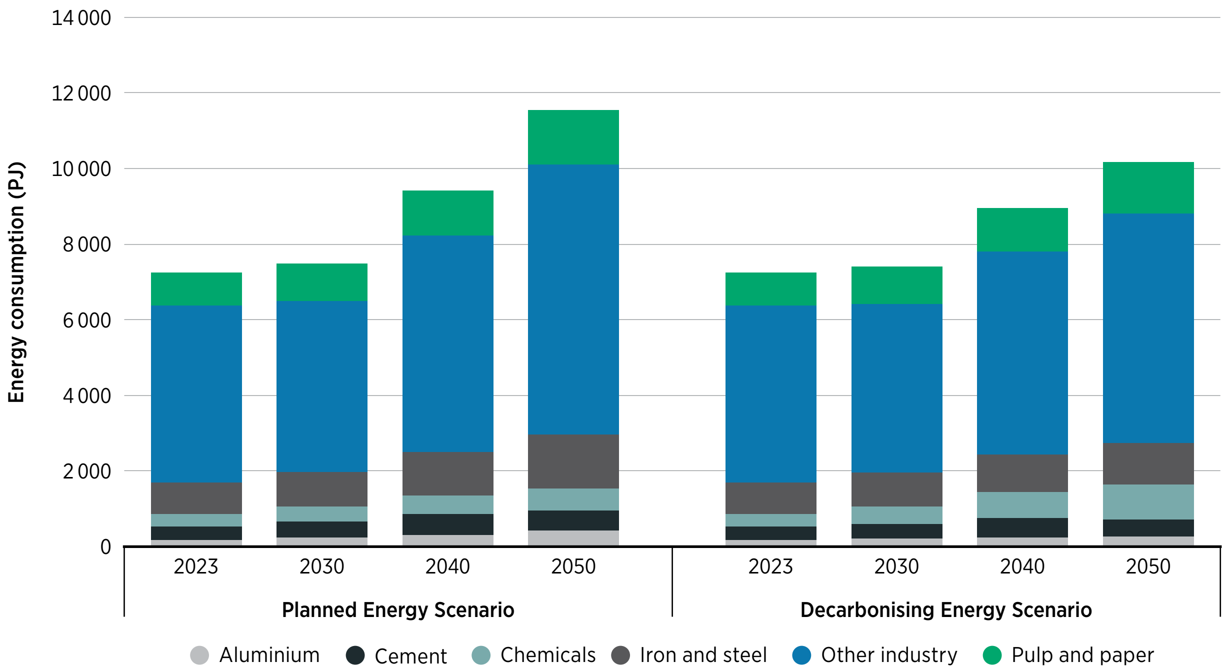
Ranked according to their level of impact on regional industry, the portfolio of measures under the DES involves: 1) a switch to cleaner energy types for both process and energy activities, including electrification, bioenergy, direct uses of renewables and green hydrogen; 2) indirect use of clean electricity via synthetic fuels and feedstocks (predominantly using renewable electricity); 3) measures for the circular economy (*e.g.* recycling, the use of alternative materials for construction and manufacturing); 4) energy efficiency in processes and the deployment of the best available technologies; and 5) adequate deployment of carbon capture technologies, such as CCS and BECCS, to tackle the remaining emissions of still-functioning production plants running on fossil fuels. By 2050, the aggregate effect of these measures across all industrial subsectors is an TFEC that is 12% less than that under the PES.

In this report, five specific subsectors were modelled to reflect the structure of the overall industrial sector, considering their high-energy intensity, complexity level to decarbonise, activity input variable (*i.e.* tonnes of production) and availability of data: 1) cement (including production of clinker), 2) iron and steel, 3) chemicals, 4) pulp and paper, and 5) aluminium (including production of alumina). The remaining industry subsectors, such as food and beverages, ceramics and the production of other metals/non-metals, were grouped under “other industries”, with a simpler approach taken in terms of their energy mix.

Figure 3.2 shows a breakdown of the sub-sectors’ respective TFECs, modelled for the PES and DES by decade over the study period. The “other industries” block accounted for 65% of TFEC in the 2023 base year, while pulp and paper accounted for 12% and iron and steel 11%. This structure remains similar out to 2050, according to the PES, while in the DES, the contributions vary for certain sub-sectors. The chemical sector, for example, sees its share of TFEC increase from 5% to 9%, while “other industries” sees its share decline to 59%.

In terms of emissions, after excluding “other industries”, the largest emitter in 2023 was cement, with 21% of the sector total. This was followed by iron and steel, with 18%. Under the DES there is a major reduction in emissions in the five sub-sectors modelled, amounting to 16% of the overall sector emissions budget by 2050, with the “other industries” block accounting for the rest.

**Figure 3.2** Final energy consumption in the industry sector (PJ) under the PES and DES, by sub-sector, 2023-2050



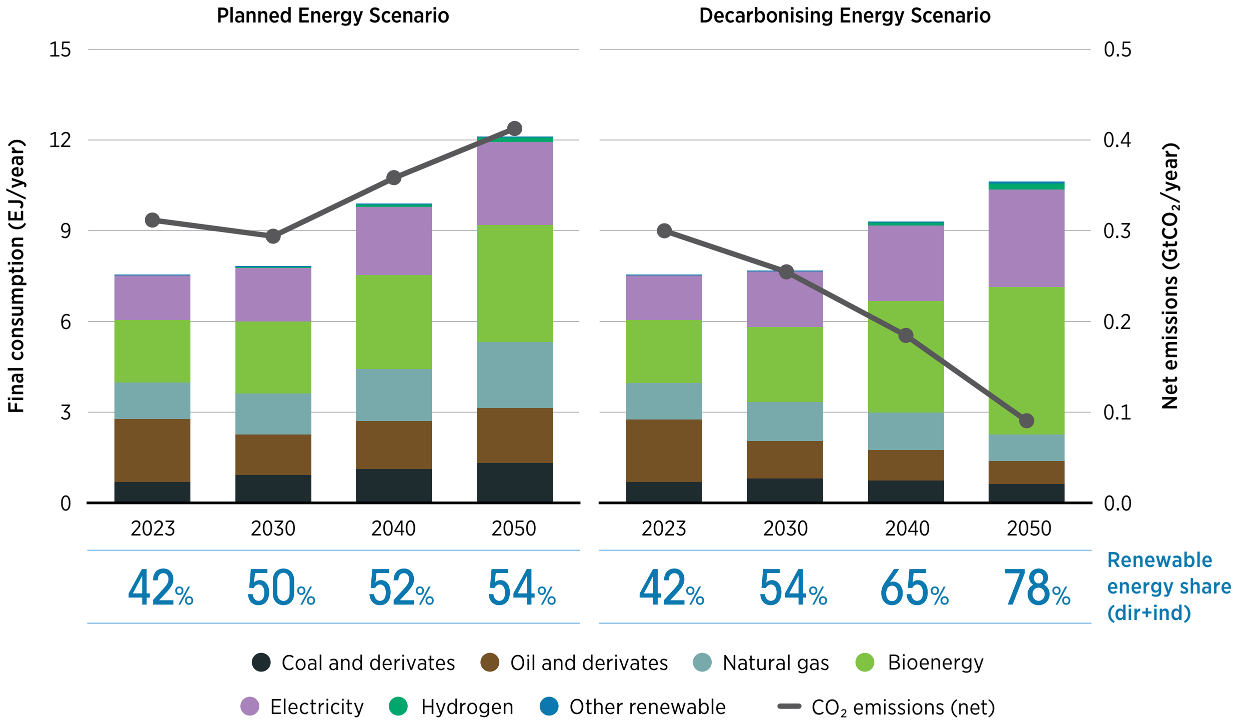

**Note:** The figure includes energy demand for non-energy uses, such as in coke ovens, blast furnaces, chemical fuels and feedstocks, along with industry co-generation.

The region’s industrial sector energy mix varies over the study period under both the PES and DES, as shown in Figure 3.3. This evolution has the following characteristics:

- Electricity, which is currently used mostly for running machinery and appliances, grows from 19% of sector’s final consumption (energy and non-energy) today to 23% under the PES by 2050. Due to a major deployment of technologies based on electricity – such as electric arc furnaces in steel production – electricity’s share rises to 30% under the DES, with electricity largely based on renewables.

- Renewables, such as sustainable bioenergy and solar thermal, are also used directly in industrial sub-sectors for both production feedstocks and low-temperature processes. The 2023 contribution that renewables make to the sector's final consumption totals 28% (mainly bioenergy), with this reaching 32% by 2050 under the PES. Under the DES, direct uses of renewables cover over 45% of industrial energy demand by 2050. When indirect uses of renewables such as electricity are added in, their overall contribution accounts for 78% of the industrial energy mix under the DES.
- Fossil fuels also vary over the study period. In 2023, these energy types accounted for a total of 53% of industrial final consumption, led by oil derivatives at 27% and natural gas with 16%. Under the PES, by 2050, fossil fuels' contribution declines to 44%. Under the DES, the aggregated effect of sector measures further decreases dependency on fossil fuels, leaving their share at 21% of the industry energy mix by 2050.

**Figure 3.3** Final energy consumption (EJ/yr) and $CO_2$ emissions ($GtCO_2$/yr) in industry sector under the PES and DES, by energy source, 2023-2050




**Notes:** Figure includes energy demand for non-energy uses, coke oven, blast furnace, chemicals fuels and feedstocks along with industry co-generation. Renewable energy share includes direct uses and contributions in the supply side (electricity/heat/green hydrogen generation); dir = direct; EJ = exajoules; $GtCO_2$ = gigatonnes carbon dioxide; ind = indirect.

With respect to $CO_2$ emissions, under the PES, these decline slightly in the short-term, yet by 2050 they increase by 32%, compared to the 2023 level of 310 $MtCO_2$. Under the DES, however, there is a reduction in emissions of 72% with respect to the PES by 2050, and a reduction of 63% compared to 2023 (Figure 3.3). This decline is feasible given the support of carbon capture technologies and the bioenergy-based technologies deployed during the last decade of the study period. The latter are implemented as a retrofit to all conventional iron, steel and cement production plants that are still operating in 2050. The measure allows a cumulative capture of around 800 $MtCO_2$ across the 2040-2050 period.

KPIs for the region's industrial sector are presented in Table 3.1. In terms of the investments in new installations and retrofits, the requirements are 10% higher under the DES than under the PES, with the former totalling a cumulative USD 223 billion and the latter USD 203 billion.

**Table 3.1** Industry sector KPIs for achieving the PES and DES, 2023-2050

| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **KPI.02 RENEWABLES** | | | | | | | |
| Biomass (incl. Feedstocks) (EJ) | 2.1 | 2.4 | 3.1 | 3.8 | 2.4 | 3.2 | 4.0 |
| Share of renewables in final consumption[1] (direct and indirect uses) | 42% | 51% | 53% | 53% | 54% | 66% | 78% |
| **KPI.03 ENERGY CONSERVATION AND EFFICIENCY** | | | | | | | |
| Total final consumption (EJ) | 7.5 | 7.8 | 9.9 | 12.1 | 7.7 | 9.3 | 10.6 |
| Energy intensity (2024 USD/MJ) | 15.8% | 15.3% | 16.2% | 16.6% | 15.1% | 15.3% | 14.6% |
| **KPI.04 ELECTRIFICATION IN END-USE SECTORS (DIRECT)** | | | | | | | |
| Electricity share (%) | 19% | 23% | 23% | 23% | 24% | 27% | 30% |
| **KPI.05 GREEN HYDROGEN AND DERIVATIVES** | | | | | | | |
| Clean hydrogen consumption (PJ)[2] | 0 | 16 | 75 | 143 | 21 | 109 | 196 |
| **KPI. 06 CCS, BECCS AND OTHERS** | | | | | | | |
| CCS (Mt$CO_2$ captured/yr) | 0 | 0 | 0 | 0 | 0 | 46 | 68 |
| BECCS (Mt$CO_2$ captured/yr) | 0 | 0 | 0 | 0 | 0 | 6 | 22 |
| **EMISSIONS** | | | | | | | |
| $CO_2$ emissions with carbon capture and removal (Gt$CO_2$/yr) | 0.31 | 0.29 | 0.36 | 0.41 | 0.27 | 0.20 | 0.12 |
| **TOTAL SYSTEM COSTS[3]** | | | | | | | |
| Cumulative investment in infrastructure (2024 USD billion) | - | 37 | 83 | 83 | 48 | 97 | 78 |

Notes:

[1] *Values include non-energy uses.*

[2] *Clean hydrogen consumption refers to direct use of green and blue hydrogen in industrial processes.*

[3] *Total system costs per column refers to cumulative value per period, as follows: 2030 covers 2025-2030, 2040 includes 2031-2040, 2050 corresponds to 2041-2050.*

$CO_2$ = carbon dioxide; EJ = exajoules; Gt= gigatonnes; MJ = megajoules; PJ = petajoules; Mt = megatonnes; USD = United States dollar; yr = year.

In the following sections, key measures and findings for the five selected sub-sectors are presented in detail. These are complemented by information on the level of estimated investment, the impact on emissions and the market opportunities.

### 3.2.1 Cement

Cement manufacture involves different kiln designs, while clinker production is of two basic types: "dry" and "wet", the difference depending on the raw materials' moisture content. In South America most of the clinker production uses the "dry" process.

In 2023, around 193 Mt of cement were produced in South America, translating into over 350 PJ, or 4.7% of the regional sector's final consumption. The subsector also contributed around 20% of the regional industry sector's $CO_2$ emissions. Brazil leads South America in cement production, with 52% of the region's output, followed by Argentina and Colombia with 11% each, then Peru with 10%.

To successfully transform the cement subsector while maintaining its competitiveness, several strategies have to be pursued simultaneously in order to take into account of the complete cement cycle. Those strategies are:

1. **The quantity of cement consumed during production must be reduced by increasing industrialisation of the output of cement and its associated products**. Currently there is a lot of wastage in the production process. This is due to untrained personnel using more cement than necessary and to inappropriate storage and transportation. The DES foresees around 20% less use of cement than under the PES by 2050.

2. **Complemented by the practices of the circular economy, the use of additives and fillers to substitute for clinker should be increased.** Conventional clinker can be partially substituted for by alternatives known as "supplementary cementitious materials". Most of these materials are waste from other production processes, with examples including blast furnace slag, coal fly ash, red mud and calcined clay. Bearing in mind that most of these types of waste come from industries that will also be decarbonising, the introduction of calcinated clays is likely to play the key role. Other substitution methods and materials are also currently under investigation or being tested, although the availability of these alternative materials in each country and the national standards applying to cement also have to be considered. Under the DES, there is an important reduction in the use of clinker in cement by 2050. Indeed, by then the DES sees the clinker-to-cement ratio drop to 52% from a current regional average of approximately 73%.

3. **Energy efficiency measures in cement production should be encouraged by promoting the application of the best available technologies.** This will improve the efficiency of both new and existing plants. For clinker production, the addition of preheater and pre-calcination stages to the current process by using dry kilns could boost efficiency. Under the DES, the implementation of these measures reduces specific energy consumption from the regional average of 4.3 GJ/t to 3.3 GJ/t by 2050.

4. **Alternative fuels for clinker production, such as waste and biomass, should be used to replace fossil fuels more frequently.** In 2023, the regional thermal substitution ratio – the percentage of energy supplied by alternative fuels rather than fossil fuels in high temperature processes – was 10%. By 2050, this would rise to 14% under the PES and 55% under the DES.

5. **$CO_2$ removal measures, such as CCS-CCUS and BECCS technologies, should be applied, particularly to capture process emissions**. These represent around 60% of the subsector's total emissions.[40] Under the DES, a post-combustion technology starts functioning from 2040 onwards, securing 86% of the captured emissions. A cumulative capture of 583 $MtCO_2$ would be achieved over the period 2040-2050.

The deployment of the above energy measures in the DES would allow emissions in the cement subsector to be cut by 98% by 2050, compared to the PES, and 97% compared to the 2023 base year. Average annual investment in infrastructure for this under the DES is estimated at USD 2.8 billion over the study period.

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[40] *$CO_2$ removal measures capture emissions from both calcination and energy use through methods such as post-combustion chemical absorption. Further information is available from the IRENA web page, www.irena.org/Decarbonising-hard-to-abate-sectors-with-renewables-Enablers-and-recommendations/Industry-sector/Cement.*

### 3.2.2 Iron and steel

Steel manufacturing includes: primary production, in which iron ore is used as the main input and is then processed into an intermediate material, such as pig iron or sponge iron, for crude steel production; and secondary production, which uses recycled steel – or scrap – as the input for electric arc furnaces (EAFs).

According to ALACERO and the World Steel Association, in 2023, the region produced approximately 41 Mt of crude steel. Most of this was primary production using one of two methods: coke blast furnaces and basic oxygen furnaces, mainly concentrated in Brazil and dominating the market, with a 70% share of total regional steel production that year; and natural gas direct-reduced iron with electric-arc furnaces, mostly in Argentina, given the country's particular resource base. This accounted for around 5% of total steel output. Secondary production (scrap-EAFs) accounted for approximately 25% of total crude steel production that year.

In terms of countries, Brazil is the region's main steel producer, with around 80% of the total, including the manufacture of pig iron for exports. Argentina follows with a share of 12%.

Regarding the subsector's share of the regional sector's energy balance, the iron and steel industry consumed 815 PJ (11% of regional sector's final consumption) in 2023 and accounted for around 18% of the regional industrial sector's $CO_2$ emissions. This shows the subsector's high dependence on fossil fuel-based technologies.

As with the cement industry, a portfolio of measures should be considered for iron and steel making. These would not only aim at decarbonising the subsector, but also at increasing regional competitiveness in the international market by providing "green" products.

The energy transition avenues for South American steel are therefore as follows:

1. **Practice the circular economy**. The next few decades are expected to see regional steel production increase by approximately 2%/year. Total output will therefore rise from over 41 Mt in 2023 to close to 75 Mt in 2050. Under the DES, the application of circular economy practices over the long-term leads to a reduction of more than 10% in steel output by 2050, compared to the PES, with the share of the total taken by scrap-EAF increasing slightly, to 28%.
2. **Current and new installations need a structural shift with renewables displacing fossil fuels for both energy consumption and reducing agents**. Given the clean energy resources of the region, the share of final consumption in the steel subsector taken by renewables (bioenergy, solar and other renewables, renewable energy-generated electricity and green hydrogen) rises from 21% in 2023 to 33% in 2030 and 65% in 2050 under the DES. With the implementation of cleaner technologies and energy efficiency measures, the TFEC of the subsector would reach 0.9 EJ in 2030, and 1.1 EJ in 2050 (2% and 22% less than the levels under the PES for the same respective years). As South American countries are in the emerging market stage, the expansion of production facilities with cleaner, innovative technologies would bring a range of opportunities to the region. These include: access to new markets, increasing trade, re-industrialisation of the sector, and a variety of beneficial socio-economic factors.
3. **CCS should be considered as an alternative to further reduce emissions from those fossil-fuel based facilities that are still operating in 2050.** These legacy assets include blast furnaces, basic-oxygen furnaces and natural gas direct reduced iron processes. The DES applied this measure to the 2040-2050 period, with cumulative carbon capture reaching around 182 $MtCO_2$.
4. **Relocate industries**. As mentioned in previous IRENA studies, countries with abundant and low-cost renewable resources such as Brazil present a valuable opportunity for sustainable iron ore mining and the manufacture of green iron.

The deployment of the above energy measures under the DES would cut emissions in the iron and steel subsector by 96% by 2050, compared to the level under the PES at that date, and 95% compared to the 2023 base year. Average annual investment in infrastructure under the DES is estimated at USD 0.6 billion over the study period.

### 3.2.3 Chemicals

The chemical and petrochemical industry is a complex sub-sector for energy modelling due to the many different products and processes in its heterogenous composition. This is in addition to the complexity resulting from the non-energy and energy uses of its products. These range from the manufacture of cleaning, pharmaceutical and agricultural materials (such as fertilisers) to energy carriers for international bunkering and trade.

In order to assess the decarbonisation pathways of the chemical industry, processes pertaining to selected products, such as ammonia and ethylene, were modelled separately for key countries. According to country-based statistics (public information available in the websites of the energy-related and sectoral entities), Brazil, Argentina and Colombia produced around 2.6 Mt of ammonia and 4.6 Mt of ethylene between them in 2023.

Moreover, the energy and non-energy needs of overall production accounted for approximately 600 PJ in 2023, according to the key countries' energy balances (Argentina, Brazil and Colombia). In terms of the energy mix of the subsector, oil products dominated the sector's final consumption, with a share of 46%, followed by natural gas with 33%, electricity with 19%, coal with 2% and bioenergy with around 1%. This energy distribution led to over 17 Mt of energy and process $CO_2$ emissions by the subsector that year.

Multiple actions would need to be implemented for the decarbonisation of the chemicals sector. This should also be done while raising the competitiveness of its exports and increasing local production for further coverage of national demand.

The following energy transition avenues therefore present themselves:

1. **Switch to renewable energy, including green hydrogen.** The overall effect of substituting fossil fuels in the production of ammonia, methanol, ethylene and other chemicals would be to increase the share of renewables (direct and indirect uses) in the subsector's energy matrix from 25% in 2023 to more than 80% in 2050, under the DES. Furthermore, due to the high deployment of bioenergy carriers for both energy and non-energy uses, this share could reach around 50% of the subsector's final consumption by 2050, while fossil fuels would be cut to 18%. In addition, clean hydrogen is included in the energy matrix, contributing 1% in 2050, considering current initiatives in the region (Stancu *et al.*, 2023).

2. **Implement energy efficiency measures and electrification of technologies in chemical processes.** Electricity's share in the final consumption of the subsector would increase to 28% by 2030 and 32% by 2050 under the DES, due to the introduction in the long-term of electrolysis or electrochemical routes (depending on the chemical). In absolute terms, the final consumption of the subsector is expected to increase under the DES, compared to the PES, as the chemical industry foresees an increase in production capacity to balance the trade of input materials, such as ammonia for fertilisers. Production of these is expected to double by 2050, compared to 2023. This assumption would lead to a 2050 final consumption that is more than twice that expected under the PES for that year, at 1.4 EJ.

3. **CCS and BECCS solutions to complement the decarbonisation of the subsector should be implemented.** Under the DES, cumulative capture reaches the order of 36 $MtCO_2$ over the period 2040-2050.

By 2050, the deployment of the above energy measures under the DES would lead to a decline in emissions of 87% compared to that expected under the PES, and 77% compared to the 2023 base year. Average annual investment in infrastructure (new and retrofit) under the DES is estimated at USD 0.35 billion over the study period.

These results and estimations correspond to the non-energy uses of chemicals. Further details and insights on the use of chemicals, such as ammonia, for international bunkering and in the hydrogen trade are presented in Chapter 7 below.

### 3.2.4 Pulp and paper

The pulp and paper industrial process is divided into papermaking and pulping. These can both occur in the same facility, if it is an integrated plant, or they can occur separately. Paper and its products can be produced either from virgin fibres or by using recycled fibres from paper and cardboard that has been collected.

The term "recycling" can either be used for the process of collecting and sorting paper and cardboard or for the process where these materials are used as inputs for the manufacture of paper, cardboard and its derivatives. Today, recycled paper scraps represent approximately 60% of the input materials used for paper production in the region.

Usually, writing paper is made from virgin fibres, while recycled fibres are used to produce toilet paper and carboard, which have a lesser quality. Pulp from virgin fibres can be produced via a chemical process (known as the Kraft process) or mechanical ones. Pulp production from recovered fibres requires around 35% less energy compared to virgin pulp. However, this does not mean that this process results in lower emissions than with the Kraft process. Kraft mills may meet most or all their energy needs from by-products such as black liquor and may even be net exporters of energy. During the recycling process, however, there are no by-products available, so those processes mostly rely on fossil fuels.

In 2023, around 33 Mt of paper and 71 Mt of pulp were produced in South America, corresponding to 12% of the regional industry final consumption (861 PJ). The subsector also accounted for 3% of the region's industrial sector $CO_2$ emissions. Brazil leads the region in paper production (pulp as well), with around 65% of the total tonnes of paper produced, followed by Argentina, and Chile and Colombia with similar levels.

Although the pulp and paper industry rely mostly in biomass, outlined below are several measures that can be applied to make the process more sustainable:

1. By **increasing the collection rate of used paper and cardboard** discarded by households and by large, medium and small generators, a circular economy can be targeted. This would lead to an increase in the recycling rate and recycled pulp production.
2. By **promoting the installation of integrated plants**, rather than pulp or paper mills, black liquor production can be used to meet the energy requirements of both processes. Integrated plants are more energy-efficient than separate pulp and paper mills, as drying can be avoided.
3. Indeed, as drying accounts for a large share of the subsector's energy use, **electrification of the drying process can cut emissions**. The use of electric boilers can also reduce dependence on fossil fuels. The DES sees an increase of more than 65% in electricity usage for the pulp production with respect to 2023.

The deployment of the above energy measures under the DES would lead to a 45% reduction in emissions in the pulp and paper subsector by 2050, compared to that achieved under the PES and over 35% compared to the 2023 base year. The annual average investment in infrastructure under the DES would be almost USD 1.9 billion over the study period.

### 3.2.5 Aluminium

In common with iron and steel production, there are two types of aluminium manufacture: primary production, in which bauxite is used for the process and alumina is the intermediate material; and secondary production, with recycled aluminium as the input.

According to 2023 statistics from the IAI and ABAL, out of the approximately 2 Mt of aluminium produced in South America, primary production accounts for 73%. This is subdivided into 50% from pre-baked technology, mainly in Brazil and Argentina, and 23% via Soderberg technology, with this only in use in Brazil. Secondary production accounts for 27% of total regional aluminium making. Moreover, Brazil is also a major global producer of bauxite, alumina and aluminium, with more than 80% of the country's production of alumina currently exported (ABAL, 2023).

In terms of the subsector's TFEC, aluminium production reached 176 PJ (or over 2% of regional industry final consumption) in 2023 and accounted for around 2.5% of regional industry sector $CO_2$ emissions. This indicates the high fossil fuel dependency of alumina production via the Bayer process.

In order to decarbonise alumina and aluminium production and enhance the region's ranking in the global market, the following solutions are proposed:

1. **Further deploy circular economy practices, such as recycling**. Over the next few decades, regional aluminium production is expected to increase by approximately 3%/year, from around 2 Mt in 2023 to around 4.3 Mt in 2050. Under the DES, circular economy measures are applied over the long-term, following the global roadmap presented by the IAI, with almost half of regional production based on recycling material by the end of the period (IAI, 2021).
2. **Accelerate the displacement of fossil fuels by renewables for current and new installations, mainly in alumina processing**. Given the clean energy resources of the region, under the DES the share of the final consumption in the subsector taken by renewables (bioenergy, solar and other renewables, renewable energy-generated electricity and green hydrogen) rises from 36% in 2023 to 40% in 2030 and 75% in 2050. In this scenario, the implementation of cleaner technologies and energy efficiency measures sees the final consumption of the subsector evolve to 235 PJ in 2030 and 263 PJ in 2050. These figures are 7% and 37% less than those that would be achieved under the PES for the same respective years. Moreover, as South American countries are already major contributors to the alumina and aluminium trade, this trend continues over time under the DES. At the same time, a balance of imports and exports of aluminium is also envisaged as one of the benefits of the energy transition. This allows more production using the region's own resources, which in turn has an impact on emissions reduction, in addition to contributing to an improved socio-economic panorama.
3. **Develop and deploy innovative solutions, such as inert anodes**. These can be used instead of carbon anodes in aluminium production. The DES includes this measure as a long-term retrofit, with this technology accounting for almost one-third of production by 2050 (MCTIC, 2017; IRENA, 2025b).

By 2050, the deployment of the above energy measures under the DES would reduce emissions in the aluminium subsector by 79% compared to the level achieved by the PES, and 42% compared to the 2023 base year. This would be the case even if an increase in domestic production was undertaken in order to reduce the quantity of imports. The average annual investment in infrastructure under the DES is estimated at USD 1.8 billion over the study period.

## 3.3 POLICIES FOR INDUSTRY SECTOR TRANSFORMATION

Electrification provides an opportunity to reduce emissions and enhance efficiency in industrial processes, particularly those requiring low- to medium-heat (defined as up to 500°C). Given the region's high potential for renewable energy, Scope 2 emissions can more easily be reduced by improvements in grid infrastructure. However, the decarbonisation of industries such as steel and cement presents challenges and needs new technologies, alternative fuels and substantial investments.

Overall, the South American industrial sector also provides limited guidance in terms of energy efficiency measures such as labelling schemes or minimum standards. This highlights how government leadership and policies are essential in creating and stimulating an adequate environment for industry decarbonisation. Reducing industrial emissions also requires a radical shift in how materials are produced, consumed and disposed of.

Most of the industrial policy recommendations below are general and apply to all sectors. The policies presented are complemented by the cross sector policies detailed in Chapter 8. More specific directives can be elaborated to support hard-to-abate sectors in their net-zero pathway, as detailed in the following sections.

### 3.3.1 Cross-sector policies

- **Establish comprehensive decarbonisation roadmaps.** Long-term planning is essential to guide industrial decarbonisation and align infrastructure development with evolving technology and energy needs. Governments should develop clear roadmaps with defined targets and timelines, supported by co-ordinated grid expansion plans to ensure timely and reliable access to clean electricity. Streamlined permitting processes and integrated "one-stop shops" can accelerate project implementation. Planning must also include workforce reskilling initiatives to support the adoption of new technologies and ensure a just transition for industrial workers.
- **Provide access to renewable energy and promote a simplified permitting regime** for the deployment of renewables on industrial sites.
- **Provide tax incentives to foster CCS.** Develop the $CO_2$ transport infrastructure and long-term storage sites to ramp up the implementation of carbon capture.
- **Set energy efficiency targets.** Governments in South America can strengthen performance standards and offer targeted financial incentives for industrial upgrades. Issuing tax credits for circular economy practices, such as scrap-based steel production, can further reduce emissions and resource use. Recycling targets, tax benefits and low-carbon public procurement criteria can drive demand for more efficient, sustainable industrial processes while fostering innovation and local value creation.
- **Incentivise technology development.** As existing heavy industry is very mature, there is natural risk aversion in the adoption of new technologies. Usually, innovation in industry requires pilot projects and long-term testing to validate its effectiveness and the sufficiency of its financial returns. Governments and partners should therefore support R&D and demonstration projects to raise the technology readiness level of solutions such as CCUS, green hydrogen applications and biofuel-compatible retrofits. R&D networks provide knowledge sharing and contribute to regional integration and resource optimisation. A shared regional vision among industrial electrification stakeholders can accelerate the development of joint action plans and optimise demand, especially in the case of industrial clusters.
- **Establish a network for knowledge sharing.** This should bring together industry, academia and development banks.

- **Establish new green markets.** As many solutions are still not mature enough, it is important to incentivise new markets for green products. Mandates, such as those for biofuels, are particularly effective, as well as public procurement and incentives for shared procurement for low carbon content products. Low carbon public procurement criteria can establish standards for buying green products and services, promoting sustainable industrial ecosystems. These policies help to overcome market barriers, create jobs and support value creation. Financing options should be made available to enhance this support, as well as tax credit benefits, when possible.
- **International co-operation is crucial.** Strengthening partnerships can help secure supply chains for critical materials. International/regional co-operation can significantly influence a government's industrial decarbonisation strategy, affecting chosen policies and their effectiveness. For instance, joint carbon pricing or border adjustments may lead to a regional ETS, a carbon tax, or a tariff impacting regional emissions. Co-operation can also help address the competitiveness issues that can arise from varying international policy ambitions.
- **Demand side auctions can help create flexibility in grid operation** and should be incentivised in all industrial sectors.

### 3.3.2 Cement

Reducing emissions in the cement sector requires a portfolio of measures. These include the following:

- **Incentivise the adoption of low carbon standards**, such as the Limestone Calcinated Clay Cement standards known as LC3, to reduce the clinker content in cement.
- **Promote the circular economy** by stimulating the utilisation of by-products from other industries as raw materials in cement production, while developing concrete with a high percentage of recycled materials. Issue directives for the reuse, recycling or recovery of construction and demolition waste.
    - Foster an increase in the use of additives and fillers to substitute for clinker by using tax incentives such as VAT reductions or exemptions.
- **Increase the utilisation and longevity of buildings** through annual tax payment decreases.
- **Promote a higher share of recycled cement** in concrete through tax incentives.

### 3.3.3 Iron and Steel

Reducing emissions in this subsector also requires a portfolio of measures, with the policies listed below now recommended:

- **Incentivise the practices of the circular economy.** Provide import tax exemption and VAT incentives for scrap.
- **Foster regional integration of the supply chain** to scale clean technology.
- **Promote green hydrogen use** via tax incentives and support the planning and establishment of industrial hydrogen hubs.
- **Introduce declining $CO_2$-intensity standards** for new capacity and major refits.
- **Set retirement dates** for unabated coal use.
- **Mandate design-for-recycling** in downstream sectors such as automotives, appliances and construction steel.
- **Develop a national/regional scrap strategy.** Formalise collection, track quality and reduce import barriers on clean scrap.
- **Launch reskilling programme** for EAF operations, electrolyser maintenance, hydrogen safety and CCUS.
- **Tie incentives** to local supplier development and community benefits.

### 3.3.4 Chemicals

- **Promote green hydrogen** by using tax incentives. Support industrial hydrogen hubs.
- **Tie incentives** to local supplier development and community benefits.
- **Set tax credits and incentives** for enhanced-efficiency fertilisers and green ammonia blending mandates.

### 3.3.5 Pulp and paper

- **Promote the circular economy** by using tax credits and by increasing the collection rate of used paper and cardboard discarded by households and large, medium and small generators.
- **Issue VAT exemptions and reductions** for recycled products.
- **Promote heat pumps, electric boilers and resistive/induction heating** for lower-temperature processes. Provide grid priority and industrial tariffs for electrified mills.
- **Set progressive recycled-content mandates** for packaging and printing grades where quality/supply allows.
- **Promote the design of recyclability.** Ban problematic coatings/adhesives that block recycling; incentivise mono-material fibre composites.
- **Promote industrial clusters** where shared heat, hydrogen and $CO_2$ networks create economies of scale.

# 04

# ENERGY TRANSITION PATHWAYS: **BUILDINGS**

## INSIGHTS AND RECOMMENDATIONS FOR THE ENERGY TRANSITION OF BUILDINGS

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ Energy demand in South America's buildings sector is expected to rise by nearly 60% by 2050 under current plans, driven by population and expanding floor area. Under the DES, improvements in energy efficiency, electrification, and renewable deployment limit this growth to below 30%. By 2050, electricity's share in buildings' final energy consumption reaches over 90%, while fossil fuels and traditional biomass fall to around 3%. | ★ Strengthen energy efficiency measures beyond appliance labelling, including building retrofits, public lighting upgrades, and efficient appliance deployment through energy service companies (ESCOs). Introduce near-zero energy standards for new buildings, ensuring integration of EV charging infrastructure and heat network connections. Link Energy Performance Certificates to tax incentives and reduced property taxes to drive investment in energy-efficient buildings. |
| ★ Cooking accounted for over 40% of residential energy use, mostly from fossil fuels and traditional biomass in 2023. Under the DES, electrification covers over 80% of households' technology stock by 2050. | ★ Expand access to electric cookstoves through concessional credit and energy efficiency funds. Conduct awareness campaigns on health benefits and promote biomethane blending mandates supported by tax incentives for local production. |
| ★ Water and space heating currently depend on natural gas, biomass, and electricity. Under the DES, water and space heating demand would be covered fully through electrification, sustainable biomass, and solar thermal systems by 2050. | ★ Promote solar water heaters and heat pumps through affordable credit, awareness campaigns, and the phase-out of gas boilers. Support innovative business models to enable large-scale adoption. |
| ★ Rising temperatures are driving greater cooling demand, with energy use expected to triple by 2050 under the PES. Efficiency improvements under the DES could cut this growth by 4%. | ★ Enforce efficiency labelling for cooling systems, offer subsidised credit for inverter retrofits, and run awareness campaigns on efficient cooling technologies. Modernise public buildings through procurement policies. |
| ★ In 2023, appliances represented about 20% and 45% of residential and commercial energy demand, respectively. Under current plans, demand could nearly double in households and triple in commercial buildings by 2050. The DES limits this growth by over 10%. | ★ Update labelling programmes and minimum performance standards, and introduce Energy Performance Certificates linked to tax incentives. Mandate utility efficiency funds and channel revenues into electrification and retrofit programmes. |
| ★ Distributed energy technologies, including rooftop solar, batteries, and smart systems, remain marginal today but have the potential to lower energy bills, ease peak demand, and support electrification, including for EV charging. | ★ Provide concessional credit, tax and VAT exemptions for rooftop PV, and enable net metering schemes. Promote electric appliance adoption and integrate EV charging infrastructure into new building codes. |
| ★ Cumulative expenditures for building decarbonisation amount to USD 782 billion under the DES between 2025 and 2050, reducing emissions by over 90% by 2050 compared to both the PES and 2023 levels. | ★ Develop comprehensive national building efficiency strategies, supported by dedicated funding and public retrofits. Implement energy efficiency levies and channel revenues into revolving funds for concessional loans and grants for building upgrades. |

## 4.1 OVERVIEW OF THE BUILDINGS SECTOR IN THE REGION TODAY

As presented in the introduction, South America is currently home to around 439 million people, comprising approximately 146 million households and an estimated floor area in commercial buildings of 5.44 billion square metres in 2023, according to IRENA internal databases. By 2050, an increase in population is projected that will reach almost 500 million inhabitants, while total floor area – both households and commercial buildings – is expected to grow over 40% by 2050.

Energy consumption in the buildings sector, covering the residential, commercial and public services subsectors, was responsible for one-quarter of the total energy consumption across end-use sectors, according to the countries' 2023 energy statistics. This consumption contributed 7% to the $CO_2$ emissions of the overall energy sector. The main energy consumption services are cooking, covering one-third of the buildings sector's TFEC in 2023, followed by water heating and space heating, with a combined share of more than 20%. These services are highly reliant on fossil fuels, while other services such as space cooling, lighting, appliances and others are mostly electrified.

In terms of the sector's energy matrix, fossil fuels, mainly LPG and natural gas, accounted for 30%, while solid biomass, typically in the form of firewood, covered 18%. Electricity contributed to around half of the TFEC, according to energy balances of the countries in 2023. The residential subsector is characterised by a lower penetration of electricity compared to commercial/services, as cooking and heating needs in households are met in less sustainable ways.

The buildings sector's energy consumption patterns across countries in South America present similarities and distinctive features, explained largely by energy access and climate profiles throughout the region. With an aggregated population representing around 70% of the overall region, Argentina, Brazil and Colombia combined accounted for 73% of the region's buildings energy demand, with shares of 46%, 19% and 8%, respectively.

As of 2023, cooking and heating needs took the lead in South American households' energy demand, which in many countries is due to cooking, due to the high reliance on inefficient and unsustainable biomass. In cold countries, on the other hand, this is mainly due to extended use of space heating and water heating. Furthermore, appliances and air conditioners have different levels of penetration, a finding that is linked to household purchasing power – although an increase is expected as and when economies develop. Finally, the services subsector includes a more diverse set of electric equipment, although fossil fuels are still relevant in heating.

Countries in South America have made different levels of progress regarding energy efficiency initiatives and improving energy access quality. In this regard, countries such as Argentina, Brazil, Chile and Colombia have been working on their institutional and regulatory frameworks to promote policies, measures and programmes, with significant progress observed in other countries as well. Examples of key initiatives across the region include:

- Energy efficiency strategies such as implementing minimum energy performance standards (MEPS) for domestic appliances and energy efficiency labels for electrical appliances and heating equipment. MEPS for air conditioning are already in force in Argentina, Brazil, Chile, Ecuador, Peru, Uruguay and the Bolivarian Republic of Venezuela.
- Programmes to reduce traditional biomass use in cooking through the adoption of electric cookstoves are being carried out in Ecuador and Paraguay.

- The phaseout of incandescent lights has been effectively implemented in most countries.
- Building energy codes that target improved building envelopes and insulation are present in Argentina, Brazil, Chile, Colombia, Ecuador, Paraguay and Peru.
- Other instruments with different levels of adoption within the region include subsidies (for efficient lamps, solar heaters and fuel switching in cooking), energy management obligations (applicable to the services subsector) and audits, among others.

This chapter highlights the main findings and key messages from the analysis of the buildings sector in South America, addressing the following guiding questions:

- What is the projected impact of changing living conditions and economic growth in energy demand up to 2050?
- Are national strategies to expand energy access aligned with the region's decarbonisation objectives by mid-century?
- What are the key policy priorities requiring attention from decision makers?

For the purpose of this report, the buildings sector comprises two main subsectors: residential (households, including houses and apartments) and commercial and services (covering public facilities, office buildings, health centres, schools, restaurants and others). Each subsector includes modules reflecting the main energy services: cooking and heating (water and space heating), cooling, lighting, and appliances and equipment.

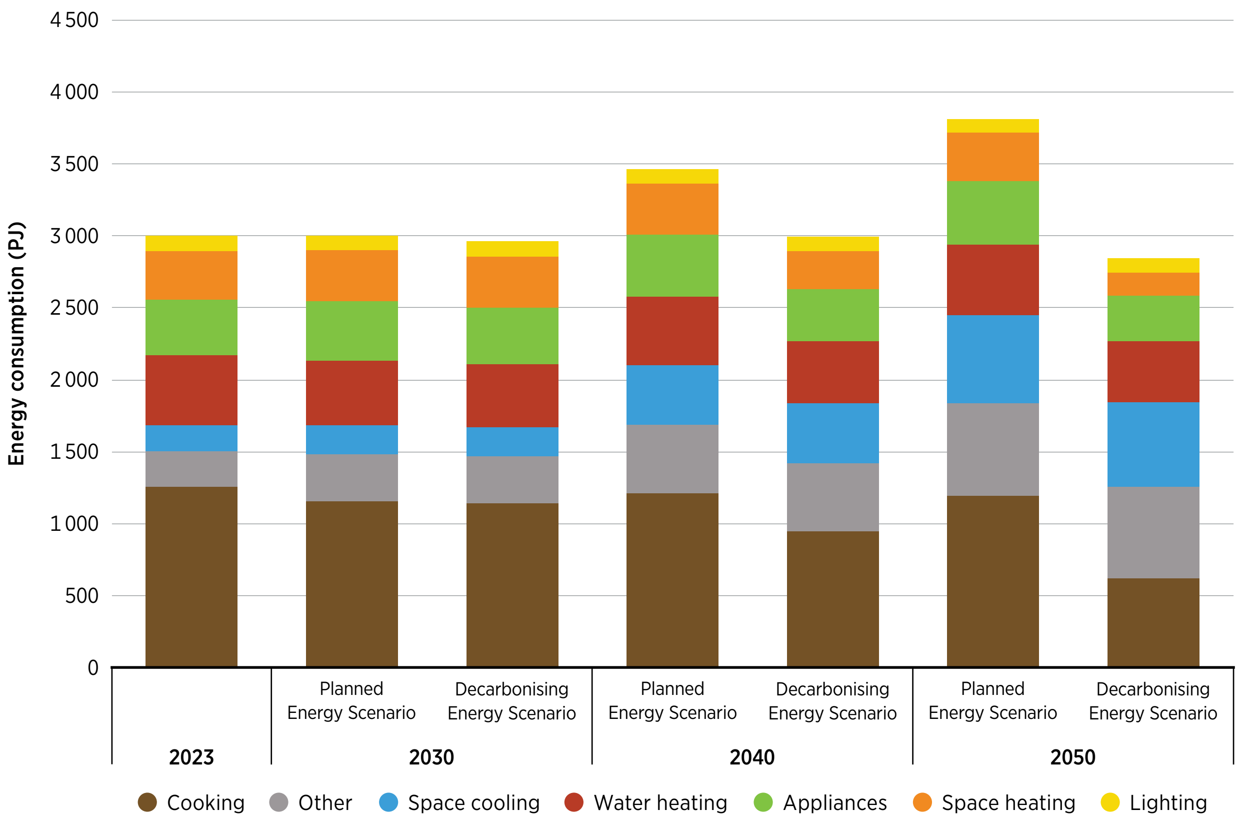
## 4.2 TRANSITION ROADMAPS FOR THE BUILDINGS SECTOR

With the expected population and floor area increase, the buildings sector's energy demand in South America would grow around 2% annually under the PES, reaching almost 6.6 EJ in 2050.

The DES envisages a highly electrified and energy-efficient future for this sector, aiming for cleaner and more sustainable cooking and heating services as its core target. Ambitious adoption of electric cookstoves and electric boilers for water heating, as well as heat pumps in regions where space heating is relevant, would drastically shift heating services' energy mix towards cleaner alternatives by 2050. Furthermore, electrification in cooking and heating would be complemented with renewable energy. This encompasses the use of sustainable biomass, phasing out current traditional methods of cooking and heating rooms using firewood, partially switching to improved burning technologies, and using bioethanol and solar thermal boilers in suitable regions. Adoption of BAT in appliances, air conditioning, lighting and equipment in the commercial subsector would also be fostered, aligned with households' improved wealth and sectoral activity growth. As a result of such measures, TFEC in buildings would be 19% less compared to the PES in 2050, with an increase of only 27% with respect to the base year.

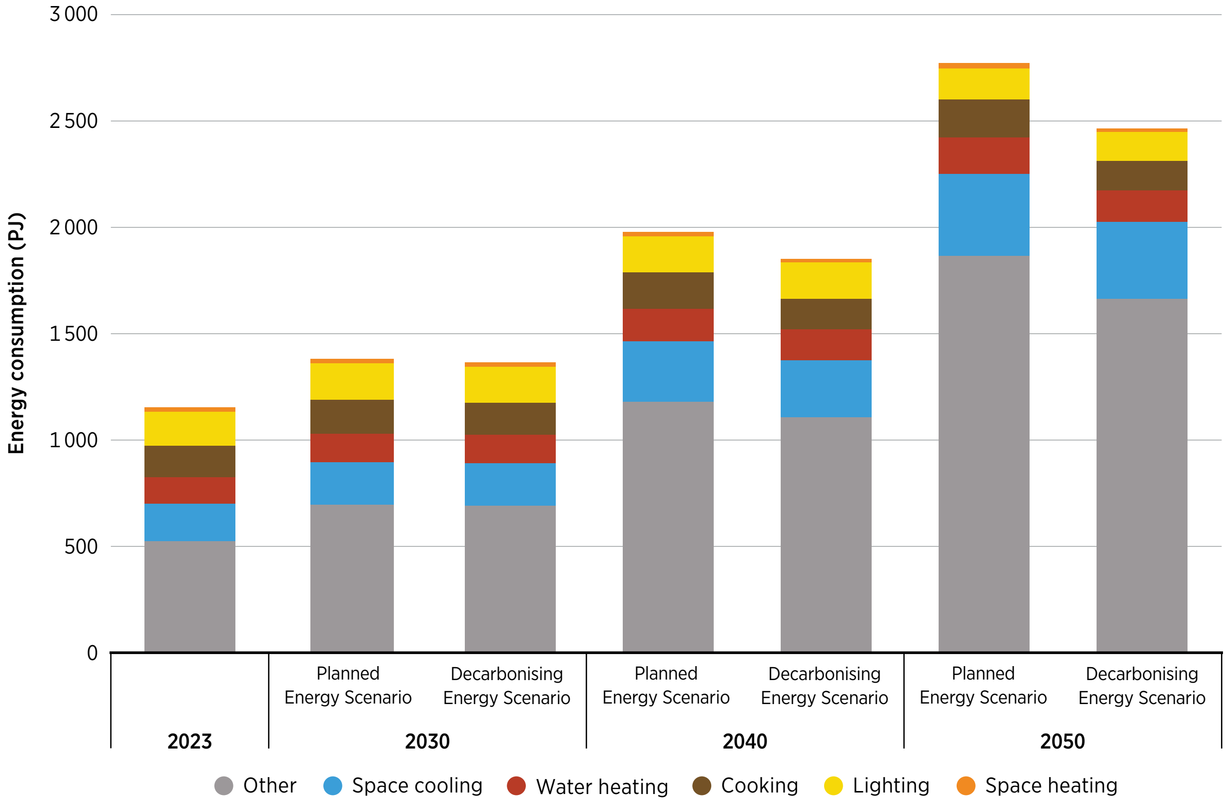
Figure 4.1 shows the leading energy service for residential consumption is cooking, with over 40%, followed by appliances and water heating, with 21% and 16%, respectively. Towards 2050, cooking and appliances will still lead, according to energy plans, while space cooling energy needs would grow the most, more than threefold from the base year value. In the DES, cooking and heating uses vary significantly, especially cooking and space heating, with a decline by 2050 of more than 50% compared to current levels.

**Figure 4.1** Final energy consumption in residential subsector (PJ) under the PES and DES, by energy service, 2023-2050



In the case of the commercial subsector (Figure 4.2), appliances and equipment dominate energy consumption in the base year with 46%, followed by space cooling and lighting, both with similar shares of around 15%. Towards 2050, energy needs for appliances and equipment are expected to see a major increase, more than threefold, while space cooling levels would double, in alignment with national plans. Under the DES, the distribution of services into the subsector's energy consumption remains similar, with lower demand (11% less compared to the PES in 2050).

**Figure 4.2** Final energy consumption in commercial and services subsector (PJ) under the PES and DES, by energy service, 2023-2050




Regarding emissions, an increase of 26% with respect to current levels is expected in the PES over the period to 2050. Aligned with fossil fuels' dominance in households when compared to the commercial subsector, the residential subsector is the main emitter in the study period (85% of sector emissions in 2023, increasing 20% by 2050 with respect to the base year). In the DES a sharp reduction is projected: a decrease of over 90% compared to the base year and a similar percentage with respect to current plans by the end of the period.

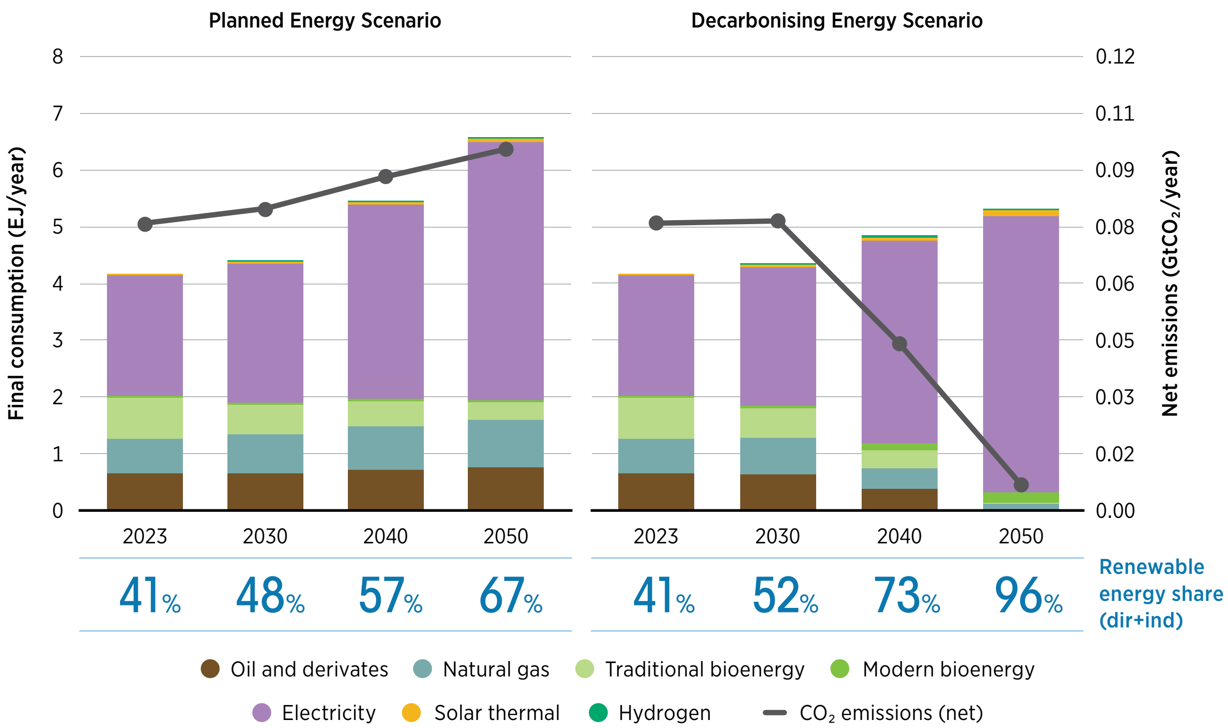
The energy mix of the regional buildings sector would be variable over the study period for both the PES and DES, as shown in Figure 4.3.

- **Electricity,** the fastest-growing energy carrier in buildings in recent years due to electrification in heating and increased ownership of appliances, would grow from an approximately 50% share of TFEC today to almost 70% in the PES by 2050. Accelerated uptake of highly efficient electricity-based technologies is expected in the DES, resulting in a share of over 90% for this carrier, and a doubling by 2050 compared to the base year.

- **Among fully electrified end-use services**, space cooling and appliances are envisaged to grow the most. The expected rise in temperatures is likely to lead to a rise in air conditioner ownership. Cooling demand would almost double in the study period, reaching around 1 EJ in the PES. Similarly, appliances and equipment energy demand would more than double, reaching up to 3 EJ in the PES by 2050, driven by improved wealth in households and further development of the services subsector. **Energy efficiency** would also be fostered and promoted. Adoption of BAT in cooling demand, given its substantial projected growth, as well as in appliances (refrigeration, motive power and others) and lighting (switching to LEDs) would also contribute to reducing energy consumption.
- **Direct renewables** in the form of bioenergy and solar thermal would complement electrification in the sector's decarbonisation process. Sustainable bioenergy is expected to be utilised mainly in households for cooking (*e.g.* improved biomass cookstoves, bioethanol cookstoves) and heating services, accounting for around 1% of energy consumption in the PES in 2050, while traditional biomass would cover 5%. Under the DES, sustainable bioenergy would reach 3%, leaving traditional biomass with a coverage of only 1%, in 2050. Furthermore, solar thermal boilers would be scaled up to support water heating decarbonisation, with a contribution of 2% in buildings' TFEC.
- **Natural gas would remain as the sole fossil fuel** by end of the period under the DES. In the PES, this fuel would still account for 13% of the sector's energy consumption in 2050, given the current planned infrastructure and its conception as "transition fuel"; however, IRENA's DES depicts a reduction of its share, supplying about 2% of the building's energy demand in 2050.

KPIs for the regional buildings sector are presented in Table 4.1. In terms of cumulative expenditures of the sector over the period 2025-2050, the DES would require around USD 782 billion, over 10% higher compared to the PES, dominated by decarbonisation measures in the residential sector (over 95% of the sector's needs).

**Figure 4.3** Final energy consumption (EJ/yr) and $CO_2$ emissions ($GtCO_2$/yr) in buildings sector under the PES and DES, by energy source, 2023-2050




**Notes:** The share of renewables includes direct and indirect (*e.g.* electricity generation) uses. The presence of hydrogen in the energy mix of buildings is due to blending in the natural gas grid in specific countries with hydrogen roadmaps/strategies indicating blending up to 10%, per international best practices to avoid modifications of existing infrastructure. Hydrogen considered for modelling corresponds to clean types (*i.e.* blue and green). dir = direct; EJ = exajoules; $GtCO_2$ = gigatonnes carbon dioxide; ind = indirect.

**Table 4.1** Buildings sector KPIs for achieving the PES and DES, 2023-2050

| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | **2023** | **2030** | **2040** | **2050** | **2030** | **2040** | **2050** |
| **KPI.02 RENEWABLES (DIRECT USES)** | | | | | | | |
| Biomass share in buildings (incl. traditional) | 18% | 13% | 9% | 5% | 13% | 9% | 4% |
| Solar thermal share in buildings | 0.4% | 0.5% | 0.6% | 0.7% | 0.7% | 1.3% | 1.9% |
| Solar thermal collector area (million $m^2$) | 6 | 8 | 12 | 16 | 10 | 22 | 35 |
| **KPI.03 ENERGY CONSERVATION AND EFFICIENCY** | | | | | | | |
| Total final energy consumption (EJ) | 4.2 | 4.4 | 5.4 | 6.6 | 4.3 | 4.9 | 5.3 |
| **KPI.04 ELECTRIFICATION IN END-USE SECTORS (DIRECT)** | | | | | | | |
| Electricity share in buildings | 51% | 56% | 63% | 69% | 57% | 74% | 92% |
| Electric cookstoves in residential (million units) | 6 | 7 | 14 | 22 | 8 | 76 | 156 |
| Heat pump installations (million units) | 0.1 | 1.4 | 2.5 | 3.9 | 1.4 | 9.0 | 18.5 |
| **KPI.05 GREEN HYDROGEN AND DERIVATIVES** | | | | | | | |
| Clean hydrogen share in buildings[1] | 0% | 0% | 0.3% | 0.5% | 0.1% | 0.7% | 0.4% |
| **EMISSIONS** | | | | | | | |
| Direct $CO_2$ emissions ($GtCO_2$/yr) | 0.08 | 0.08 | 0.09 | 0.10 | 0.08 | 0.04 | 0.01 |
| **TOTAL SYSTEM COSTS[2]** | | | | | | | |
| Cumulative expenditure (2024 USD billion) | - | 125 | 251 | 319 | 140 | 266 | 376 |

**Notes:**

[1] *Clean hydrogen consumption refers to green and blue hydrogen as blending in the natural gas grid.*

[2] *Total system costs per column refers to average annual value per period, as follows: 2030 covers 2025-2030, 2040 includes 2031-2040 and 2050 corresponds to 2041-2050; $CO_2$ = carbon dioxide; EJ = exajoules; Gt= gigatonnes; $m^2$ = squared metre; USD = United States dollar; yr = year.*

The presence of hydrogen in the energy mix of buildings is due to blending in the natural gas grid in specific countries with hydrogen roadmaps/strategies indicating blending up to 10%, per international best practices to avoid modifications of existing infrastructure.

The following sections present a detailed perspective on the decarbonisation of the buildings sector by selected energy services for the South American region.

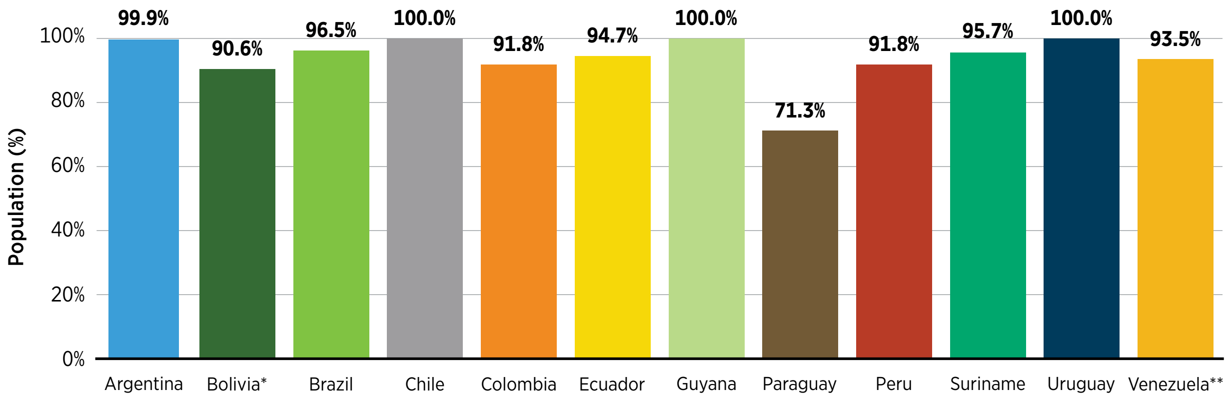
### 4.2.1 Cooking

Cooking – historically the main service in terms of energy consumption and still largely reliant on fossil fuels and traditional biomass – represented almost one-third of sector demand in 2023. Several energy plans utilise common measures such as a greater penetration of natural gas and switching from biomass to LPG, combined with a still-low shift towards electrification through electric cookstoves.

Clean cooking access is a significant challenge in South America, especially in rural areas. About 5% of the population lacks clean cooking solutions, instead relying on open fires, inefficient stoves, or harmful fuels, which mainly affect women and children. Indoor air pollution from these practices is linked to premature deaths annually across the region (IEA, 2024c) .

Figure 4.4 lists access rates to clean cooking fuels and technologies in selected countries in the region. While Argentina, Brazil and Colombia (the biggest economies in the region) have higher access to clean cooking (an average of 96%), Paraguay, Ecuador, the Plurinational State of Bolivia, Chile and Peru have an average deficit of 9%. Only 71.3% of Paraguay's population has access to clean fuels technology for cooking. Suriname and the Bolivarian Republic of Venezuela have an approximate 3.6% deficit of clean cooking fuels, implying urgent and effective policies are required. Most South American countries are more focused on subsidising gas or LPG than considering electrification (IEA, 2024d).

**Figure 4.4** South America's access to clean cooking fuels (% of population), by country, 2023




**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela

In Colombia, the 2017-2022 PAI PROURE focused on replacing wood with cleaner alternatives in rural areas, such as switching natural gas cookers to electric induction cookers. The current 2022-2026 National Development Plan aims to launch a clean cooking programme that substitutes firewood, charcoal and waste with renewable energy sources, LPG and natural gas. In 2021, 1 million families in Colombia lacked access to clean cooking (IEA, 2023d). In response, the government introduced initiatives such as subsidising LPG cylinders (Law 2128 and MME Resolution 40342/2021) and piloting firewood replacement programmes. However, challenges persist, including the affordability of LPG for users who traditionally use biomass and the infrastructure upgrades needed to support electric cooking solutions.

Brazil also faces notable challenges, with significant regional inequalities in clean cooking access. To address this, the government proposed the LPG for All Programme (Bill No. 3.335/2024), aiming to deliver liquefied gas cylinders to over 20 million families. Meanwhile, the Plurinational State of Bolivia, where access deficits improved from 18% in 2018 to 14% in 2020 (WHO, n.d.), is deploying the Electricity for Living with Dignity programme to expand electrification.

Paraguay remains in a critical situation, with around 31% of its population still relying on traditional biomass for cooking in 2022 (WHO, n.d.). This widespread biomass use contributes to severe deforestation and biodiversity loss, compounded by limited affordability of efficient electric appliances and a lack of regulatory incentives for cleaner industrial thermal energy.

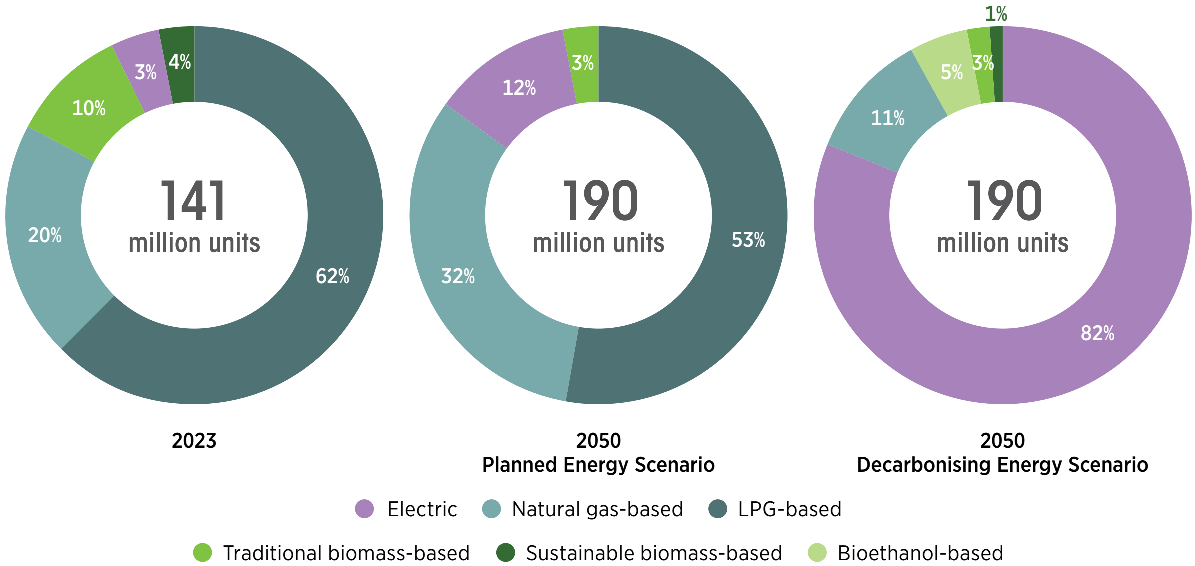
In other countries, progress is mixed. Guyana has improved access rates, from over 35% in 2000 to more than 75% in 2018 (WHO, n.d.), but expansion has slowed and achieving universal access by 2030 remains uncertain. For many smaller or less-documented countries, the continued reliance on wood and charcoal for cooking poses health threats and environmental risks.

The cooking technology mix in terms of stock in the residential subsector is presented in Figure 4.5 for the PES, DES, base year and end of study period. In the PES, a set of measures is applied based on regional features and energy plans: natural gas in cooking will expand further in countries such as Argentina, Brazil and Colombia, aiming to replace LPG use in urban areas. Furthermore, LPG is also included in countries' plans (reflected in the PES) as an alternative to improve living conditions in rural areas, replacing traditional biomass and resulting in a decrease of this carrier's share from almost half of the cooking energy needs in households in 2023 to 21% in 2050. Electric cookstove penetration of is set to grow in all countries, especially in urban areas, from less than 5% in the base year to around 12% by 2050. Despite these efforts, fossil fuel-based technologies would still capture the largest share by 2050, with around 85% of the overall cookstove stock in the residential subsector.

The cooking energy transition in residential stock under the DES would see electrification as a core measure, with electric cookstoves reaching over 80% of stock in 2050. Natural gas would still play a role given the grid expansion already deployed for this fuel, with a share of 11%. Inefficient cookstoves based on traditional biomass would be fully phased out, partially replaced with improved biomass cookstoves in rural areas with limited access to alternative fuels, while its cultural use would be preserved, accounting for 2% of the residential stock in 2050. Finally, bioethanol cookstoves are also introduced as a novel clean solution for rural populations (UNIDO, 2023), particularly in countries making use of LPG imports.

The portfolio of solutions for cooking in the overall buildings sector under the DES would imply an increase of electricity into the energy service needs from 6% to approximately 75% in 2050 (11% under the PES), while sustainable bioenergy would account for almost 15% by the end of the study period.

**Figure 4.5** Cooking technologies in residential subsector (million units) in 2023, and under the PES and DES by 2050, by energy type




**Note:** LPG = liquefied petroleum gas.

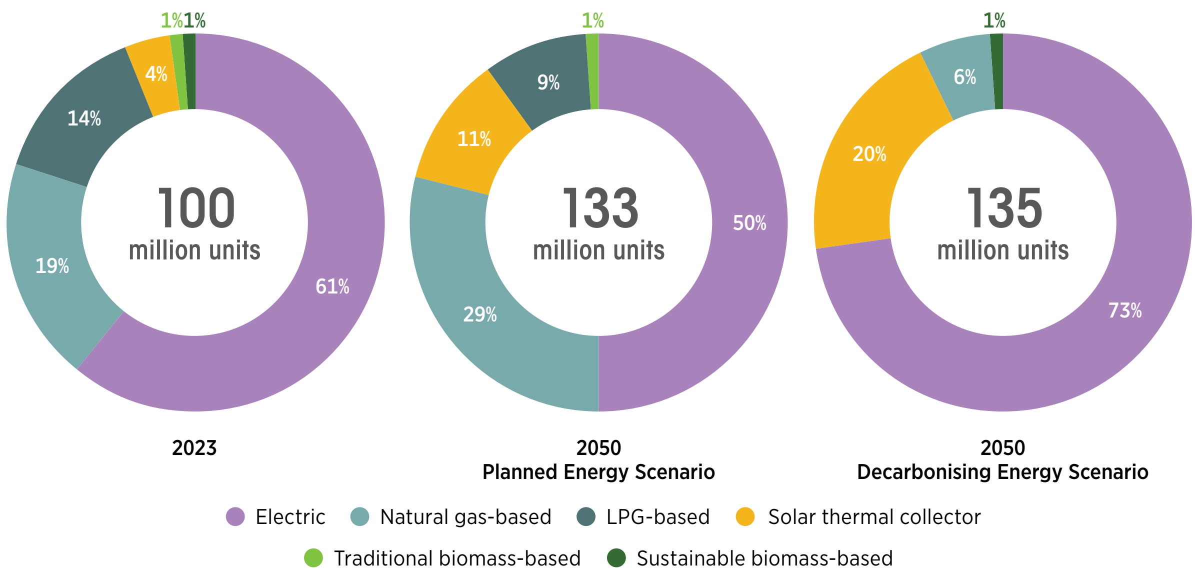
### 4.2.2 Heating uses

#### Water heating

Water heating services (comprising mainly sanitary hot water) made up around 15% of regional buildings' energy demand in 2023. Unlike cooking, biomass use for hot water is less relevant as cleaner and more efficient technologies and energy carriers are adopted throughout the region for this service. Electricity-based technologies (mostly electric boilers) covered around 60% of the water heating stock in 2023. Fossil fuels accounted for 33%, while solar thermal water heaters, installed mainly in households, made up less than 5% from sector's stock, playing a low but steadily increasing role (see Figure 4.6). This distribution of technologies shows an energy matrix in 2023 with electricity and fossil fuels contributing similar shares (approximately 45%), bioenergy carriers (traditional and sustainable) accounting for 5%, and solar thermal complementing these services at around 3%.

Electrification is envisaged as the main decarbonisation measure for water heating under the DES. This would be made possible by the use of efficient electric boilers and partially through the rollout of heat pumps in selected countries. Electricity-based technologies would see a rapid uptake under the DES, increasing their share in the overall stock share to over 70% in 2050 through widespread adoption of efficient electric boilers. Among renewables, solar thermal boilers would be strongly encouraged in suitable areas and are envisaged to achieve a 20% share in 2050, complemented by sustainable biomass boilers that would account for 1% of the overall stock. All of these measures would result in energy consumption decreasing by 7% over the study period compared to current energy levels, with electricity covering more than 70%, followed by solar thermal (17%) and bioenergy with 6%.

**Figure 4.6** Water heating technologies in residential subsector (million units) in 2023, and under the PES and DES by 2050, by energy type



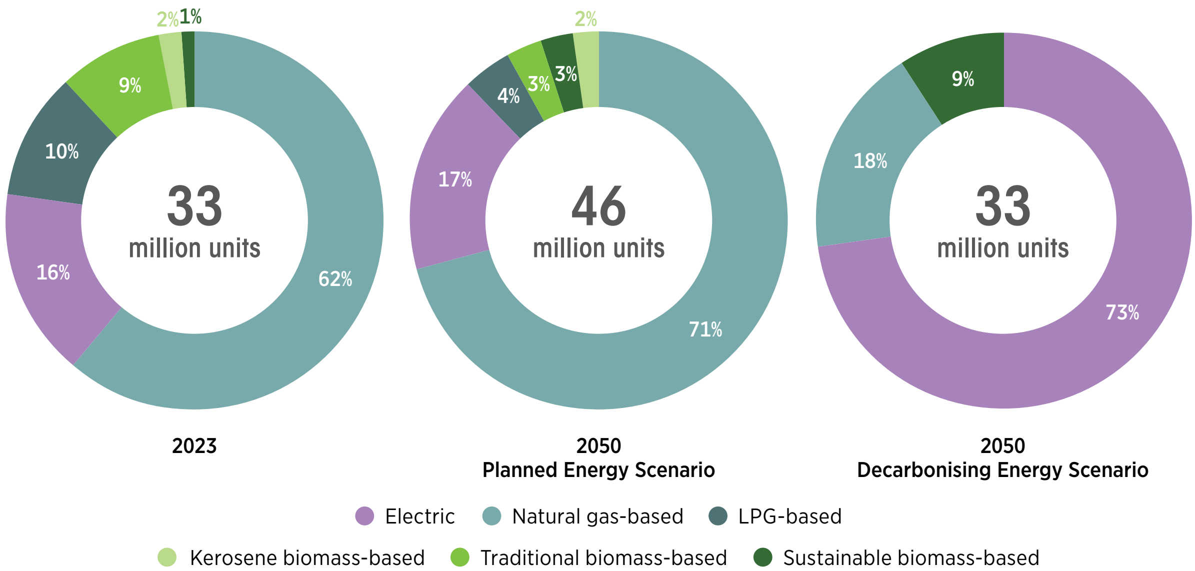

**Note:** LPG = liquefied petroleum gas.

#### Space heating

Space heating is especially relevant in most parts of the Southern Cone (Argentina, Chile and Uruguay), covering around 9% of the buildings' TFEC in 2023, which was met mainly with fossil fuels (natural gas, 57%; LPG and kerosene, 12%), complemented with firewood (around 20%) and a still low penetration of electricity through the use of electric heaters and heat pumps (10%).

The DES proposes electrification as the main measure for decarbonising space heating, led by an ambitious deployment of heat pumps and complemented by electric heaters, as well as sustainable biomass – partially replacing polluting and harmful technologies in selected regions – and modern biomass adoption in the form of wood chips and pellets (Figure 4.7). The rollout of heat pumps, which use technology that is three to four times better than current efficient natural gas boilers, would be required to drastically reduce emissions, growing from a penetration of less than 1% in 2023 to 55% in 2050. These units would mainly displace natural gas boilers and part of the conventional electric heater stock, which is intrinsically inefficient for extended use. Moreover, electric heaters would still be utilised as a replacement for unsustainable biomass heaters but at a lower extent than LPG. The deployment of these cleaner and more efficient technologies would allow for a reduction of more than 50% of the energy needs for space heating in 2050, compared to base year levels.

**Figure 4.7** Space heating technologies in residential subsector (million units) in 2023, and under the PES and DES by 2050, by energy type



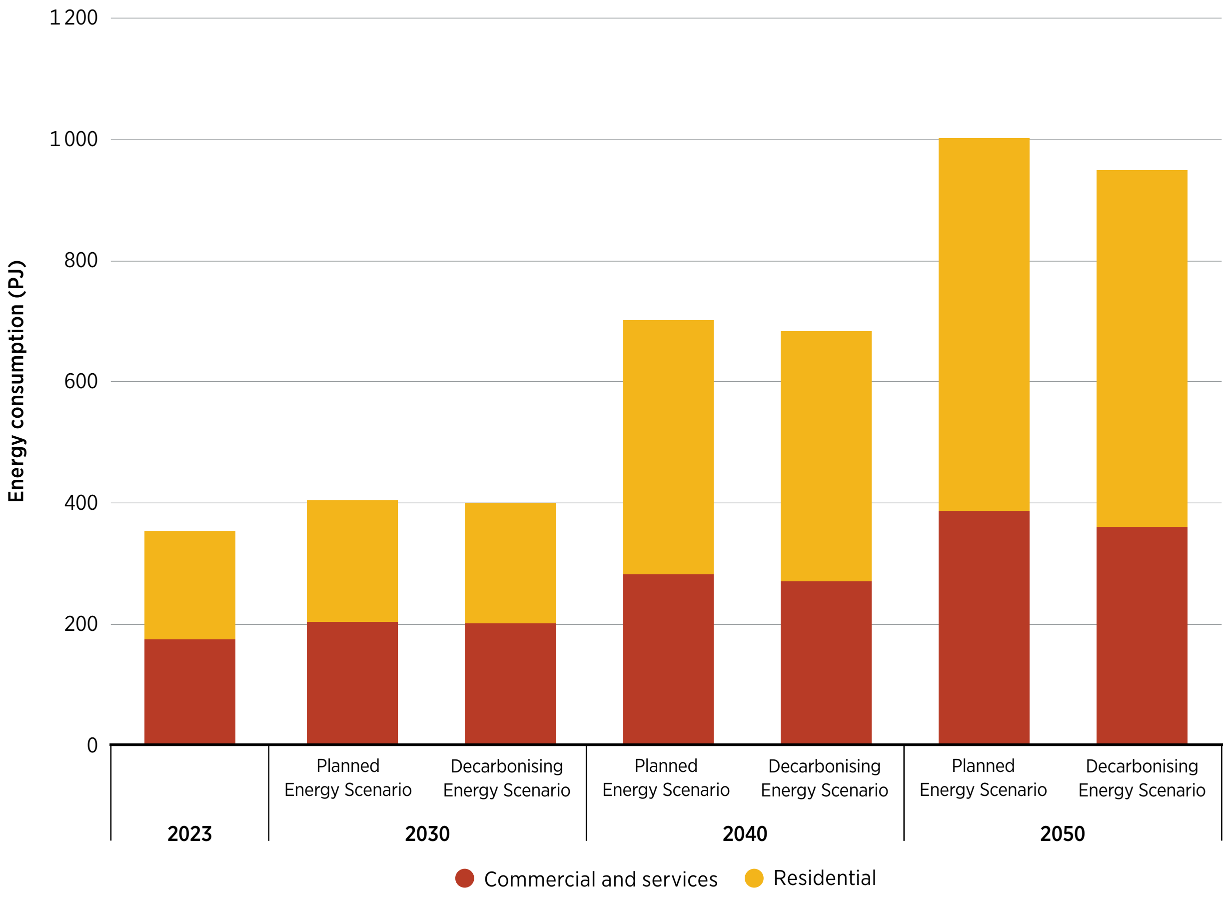

**Notes:** The DES considers less deployment of units as there is consideration of insulation improvement in buildings (Chile's energy plan – Accelerated Energy Transition Scenario) ; LPG = liquefied petroleum gas.

### 4.2.3 Space cooling

As new standards of comfort are gradually reached and annual temperatures in South America increase, a rise in the needs to cool buildings is expected. Space cooling represented around 8% of regional buildings' energy demand in 2023 (15% of commercial's TFEC and around 6% of residential's TFEC). With technology penetration anticipated to rise significantly given increased cooling degree-days and higher ownership (from around 20% in 2023 to more than 50% by 2050 as regional averages), energy demand is expected to almost triple compared to the base year, reaching 1 EJ in the PES (see Figure 4.8).

Widespread adoption of efficient air-cooling technologies[41] should be promoted, both for lowering energy bills and reducing electricity requirements at peak hours. Aligned with this ambition, the share of efficient air conditioners in the entire stock is foreseen to rapidly rise from around 60% in 2023 to over 85% in 2050 under the PES; under the DES, it would account for 95% of overall stock. As a result, in the DES, space cooling needs would be 5% lower when compared to the PES by 2050.

**Figure 4.8** Space cooling energy consumption in the buildings sector (PJ) under the PES and DES, by sub-sector, 2023-2050




**Note:** PJ = petajoules.

[41] *"Efficient" technologies per the energy modelling refer to technologies with less specific consumption, starting with labelling mandates if applied by the countries and/or BAT references.*

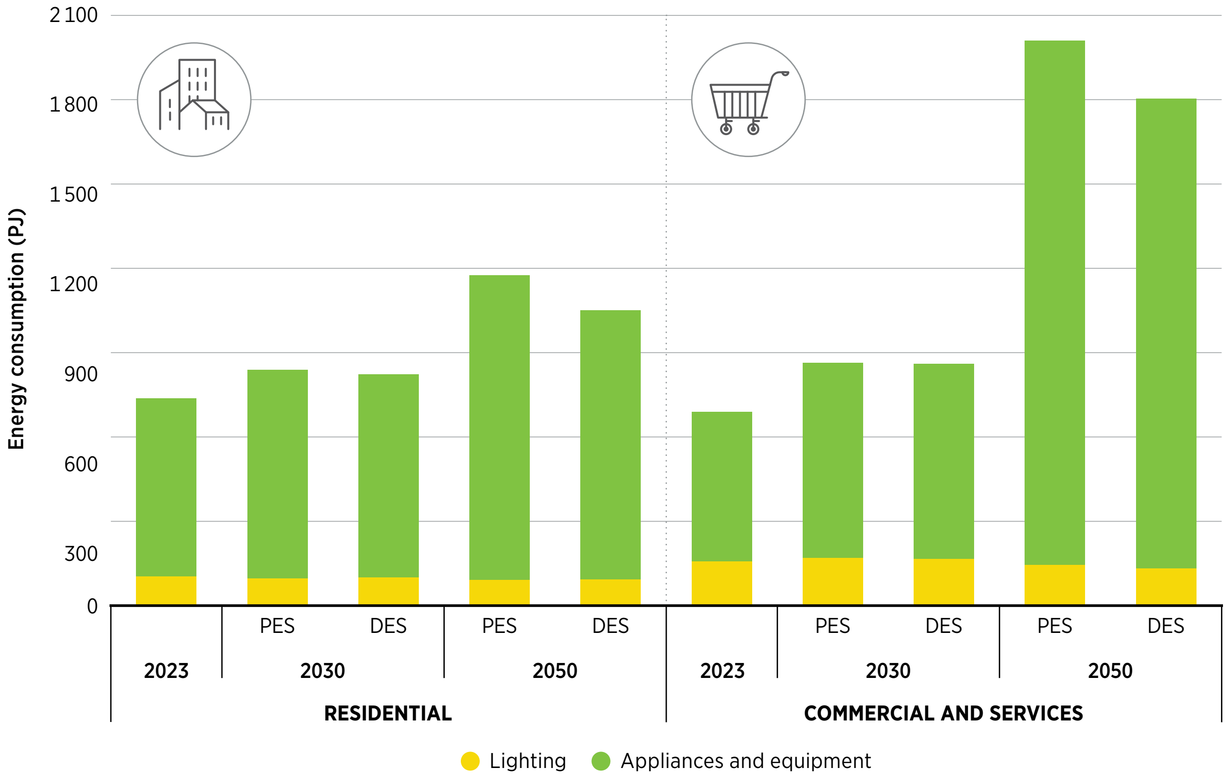
## 4.2.4 Appliances and lighting

A large share of buildings' energy demand is determined by appliances, which in households comprises refrigerators, washing machines, white and brown appliances, and lighting equipment, all of which are powered by electricity. In the commercial subsector, a more diverse set of equipment is covered, providing refrigeration, motive power, computational (data storage and management) services, communications and several other services, most of them electricity based. Nevertheless, fossil fuels (natural gas and liquid fuels) are still part of the energy mix.

As of 2023, the energy demand of appliances in addition to lighting in households accounted for 25% of the subsector's TFEC, with an estimated growth of approximately 60% by 2050 due to increased ownership as households' wealth improves throughout countries. In the commercial subsector, equipment and lighting dominated energy consumption at almost 60% in the base year. This is anticipated to rise rapidly in connection with new builds (and opportunities of data centres facilities allocation), resulting in a threefold energy demand growth under the PES. As stated in the countries' energy plans, several regulations and initiatives are currently in place to reduce energy consumption in both subsectors (*e.g.* MEPS related to buildings and technologies, a full switch to LED lights), although higher ambitions are still possible that would reach all users.

The DES portrays more stringent energy efficiency in households' appliances, particularly in high energy-consuming devices such as refrigerators, washing machines and dishwashers. Similarly, higher ownership of efficient equipment is projected in the commercial subsector, targeting mainly motive power, refrigeration and computational processes as the leading energy services in terms of consumption. These measures would result in a reduction of over 10% in appliances/equipment and lighting energy demand compared to the PES by 2050. Projected energy consumption by subsector and scenario is presented in Figure 4.9.

**Figure 4.9** Energy consumption in lighting, and appliances and equipment under the PES and DES, 2023-2050




**Note:** DES = Decarbonising Energy Scenario; PES = Planning Energy Scenario; PJ = petajoules.

### **Box 4.1** Data centres in South America: Consumption and planning

Worldwide, data centre electricity use is projected to roughly double by 2030 (about 945 TWh) (IEA, 2025c). Artificial intelligence (AI) is a dominant driver for this demand projection, but the pattern will have regional variations. South America is no exemption: electricity demand for data centres will rise sharply through 2030 and continue growing to 2050, driven first by cloud growth and then by AI workloads.

Brazil will remain the region's largest consumer of electricity for data centres, followed by Chile and Colombia as the main regional hubs. These countries will absorb most of the new regional demand by 2030-2040. Other countries in the region with smaller markets (Argentina, the Plurinational State of Bolivia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, the Bolivarian Republic of Venezuela) start from low baselines but may see a sustained growth in the demand share through 2040-2050 due to an expansion in digitalisation, edge computing and national cloud projects.

Relevant aspects to consider for satisfying the growing electricity demand from data centres are the energy carrier mix in the national electricity supply (hydro-dominated Brazil versus more fossil systems elsewhere), water constraints and grid limits (especially in drought-prone areas), and policy on energy efficiency and carbon. When implemented correctly, the last two aspects can reduce electricity demand and promote the use of on-site renewables. Electricity demand from data centres in the South American countries covered by this study is estimated to be around 36 TWh by 2030, 64 TWh by 2040 and 86 TWh by 2050, which implies that data centres will be a meaningful share of new load.

### **Box 4.2** Adaptation and resilience of cities and buildings due to climate change

Global assessments show that countries' governments need to tighten building codes, expand renovation programmes, and scale concessional and private capital for adaptation in the buildings sector. These measures would deliver resilience to heating and flooding, reduce energy consumption, and protect public finances from disaster losses. In the case of South America, development banks such as the IDB are steering grants, loans and technical assistance toward climate-resilient infrastructure in end-use sectors (including buildings) and heat mitigation, while calling for more innovative instruments to attract private finance.

Countries in South America already have policy measures for supporting the energy transition in the buildings sector. Brazil is strengthening its building energy labelling (PBE Edifica) and conformity assessment, which are useful instruments for guaranteeing the retrofit quality. Argentina has rolled out a national energy label for housing that supports municipal retrofit schemes and disclosures, catalysing upgrades in heating, cooling and hot water systems. Peru's National Adaptation Plan and Adaptation Fund proposals prioritise climate-resilient urban services and buildings, creating clear pipelines for finance. In the Guianas and the Caribbean basin (Guyana, Suriname, French Guiana), regional initiatives are advancing resilient codes and insurance/finance facilities that national governments can tap for building upgrades and disaster-ready public assets.

Technical trends shaping retrofits include passive cooling (shading, ventilation, reflective/cool and green roofs), high-efficiency electrification (heat pumps), flood-smart design (elevated equipment, backflow prevention), permeable streets, rainwater harvesting and sponge-city nature-based solutions. Cities are also piloting reflective pavements for decreasing the heat island effect. Evidence from Colombia showcases the urgency: intensifying urban heat islands raise cooling needs, making envelope retrofits and cool roofs cost-effective resilience measures.

Engagement at the national, regional and municipal levels in countries across South America is needed to pair enforceable retrofit standards with stable funding mechanisms (sovereign/municipal green bonds, concessional credit lines, results-based grants) for securing the transition to a more sustainable sector that also improves people's lives.

## 4.3 POLICIES FOR THE BUILDINGS SECTOR TRANSFORMATION

Most countries in the region have specific programmes to address minimum standards, labelling, clean cooking and cooling/heating requirements (Table 4.2). Many countries are partly addressing energy poverty and inequalities via building decarbonisation strategies (OECD, 2024). In Chile, the National Energy Policy 2050 aims for 100% low-emission heating and cooking in urban centres by 2040, and for all new buildings to achieve net-zero energy use by 2050.

Building certification policies could play a key role in advancing energy efficiency and the integration of renewable energy technologies in South America. These certifications can promote the adoption of solar water heating, rooftop PVs and climate-responsive architectural designs that improve thermal performance. Incentive mechanisms, such as reduced property taxes for higher-rated buildings, could help accelerate uptake.

Comprehensive policies are needed to decarbonise heating and cooling in buildings. These policies include updated building codes for reducing buildings' thermal load; MEPS for appliances; and mandates for the use of renewable-based technologies such as solar heaters, heat pumps and geothermal systems. These measures not only support climate goals but also offer co-benefits including improved welfare, job creation and local economic development through strengthened demand for sustainable construction and clean technology solutions. Although labelling schemes are already in force in all countries, building codes exist only in Brazil, Colombia and Ecuador. Establishing building codes for new buildings that encompass minimum energy performance requirements incorporating efficiency targets and the use of thresholds in buildings codes are among the most applied and cost-effective long-term policy strategies for reducing energy demand ('Global Monitoring of Policies for Decarbonising Buildings', 2024).

Codes perform best when they are mandatory and integrated with complimentary policies into policy packages – typically including regulatory measures (codes), incentives (fiscal or financial) and voluntary measures (green rating, education and awareness, rewards/awards) (Environment, 2023; Global Alliance for Buildings and Construction, 2020).

Fostering rooftop distributed generation through energy compensation schemes (net metering, net billing) already exists in several countries (Argentina, Brazil, Chile and Uruguay) and can be spread across the region. That, together with a clean cooking policy that provides electrical pans and improved cookstoves to users who are currently burning biomass, combines building energy efficiency with poverty reduction. Other options like biodigesters and ethanol-based solutions could also be incentivised, especially in rural areas with substantial agricultural residues to feed biodigesters and where there is already vibrant bioethanol production, such as Brazil (IEA, 2024d). Last but not least, education and information campaigns are important means to increase public consciousness and foster energy efficiency.

**Table 4.2** Energy efficiency policies and programmes across South America

| COUNTRY | 1 NET-ZERO / BUILDING CODES | 2 MINIMUM ENERGY PERFORMANCE STANDARDS | 3 APPLIANCE LABELLING | 4 COOKING — ENERGY POLICIES |
|---|---|---|---|---|
| Argentina | **Voluntary/sector roadmaps:** building codes exist but net-zero alignment still patchy; city pilots. | **MEPS present for some equipment:** coverage partial. | **Mandatory labelling for some appliances:** growing coverage. | **Clean cooking programmes (targeted):** access improving but rural gaps persist. |
| The Plurinational State of Bolivia | **Draft/limited:** basic building codes; net-zero alignment limited. | **Limited MEPS** | **Label pilots/voluntary:** many countries have labels, but coverage is lower. | **Clean cooking:** national programmes but some households remain without clean access. |
| Brazil | **Advanced/progressing:** updated building codes and strong national EE policy; net-zero building roadmaps in development. | **Relatively broad MEPS and EE regulation** (industrial/buildings); strong programmatic activity. | **Wide coverage:** INMETRO labelling + PROCEL (energy efficiency programme); many mandatory labels. | **Clean cooking roadmap (G20 Brazil work):** mostly clean fuels in urban areas, rural gaps. |
| Chile | **Relatively advanced:** progressive building codes and strong urban net-zero agendas in municipalities. | **MEPS for many appliances and building EE codes** (active updates). | **Mandatory labels and MEPS (fridges, AC, others):** strong enforcement compared to peers. | **Clean cooking:** improving access; programmes and electrification pilots. |
| Colombia | **Draft/strengthening:** building code updates ongoing; city-level net-zero roadmaps (Bogotá region). | **Growing MEPS coverage:** phased adoption. | **Energy labelling in place for many appliances:** uptake increasing. | **Clean cooking programmes** and LPG transition policies: rural electrification progress. |
| Ecuador | **Limited/draft:** building codes exist; net-zero alignment limited to plans. | **Some MEPS and appliance regulations** but coverage partial. | **Labels present for core appliances (partial).** | **Clean cooking** programmes (IDB/ United Nations support) to reduce solid fuel use. |
| Guyana | **Limited/developing:** building codes basic; climate focus on forestry/carbon. | **MEPS limited.** | **Label coverage limited/ voluntary.** | **Clean cooking:** programmes to expand LPG and improved stoves; gaps remain. |
| Paraguay | **Limited/draft:** basic building regulation; net-zero building policy limited. | **MEPS limited.** | **Label coverage limited.** | **Clean cooking:** partial programmes; biomass reliance remains in rural areas. |
| Peru | **Strengthening:** code upgrades and city programs; moves toward EE in buildings. | **MEPS present for some appliances:** expansion ongoing. | **Appliance labelling policies in force** (partial). | **Clean cooking:** active national policies to reduce traditional fuel use (rural programmes). |
| Suriname | **Limited/draft:** energy policy focus but building code updates limited. | **MEPS limited.** | **Labels: limited/ voluntary.** | **Clean cooking:** programs limited; electrification efforts ongoing. |
| Uruguay | **Moderate:** building codes and EE policies stronger than many peers; net-zero building roadmaps under discussion. | **MEPS and regulations present** (focused coverage). | **Labels and EE programmes in place** (lighting/appliances). | **Clean cooking:** high electrification, low traditional cookstove dependence. |
| The Bolivarian Republic of Venezuela | **Limited/unclear:** building code enforcement and net-zero policies weak given macro constraints. | **MEPS limited / enforcement low.** | **Appliance labelling coverage limited / patchy.** | **Clean cooking:** mixed access; data gaps. |

| COUNTRY | 5 LIGHTING ENERGY POLICIES | 6 COOLING POLICIES | 7 SPACE-HEATING POLICIES | 8 WATER-HEATING POLICIES |
|---|---|---|---|---|
| Argentina | **LED promotion and programmes** (national/subnational). | **AC standards emerging: market measures** (some MEPS). | **Relevant in the south (Patagonia):** limited national policy. | **Programmes/ incentives for efficient water heaters** (partial). |
| The Plurinational State of Bolivia | **Lighting:** LED substitution programmes (partial). | **Cooling:** limited policy (tropical zones) | **Space heating:** localised limited policy (highlands). | **Water heating:** limited policy. |
| Brazil | **Major LED programmes:** lighting efficiency institutionalised (PROCEL). | **AC MEPS and labels exist (growing):** cooling efficiency programmes under development. | **Space heating:** limited need nationally except south; some local measures. | **Water heating:** some standards and incentives for efficient systems / solar thermal pilots. |
| Chile | **Active LED and lighting standards.** | **AC efficiency standards and labelling** (well-developed). | **Space heating:** policies geared to southern regions (stoves regulation, residential emissions). | **Water heating:** incentives for solar thermal and efficient electric water heaters. |
| Colombia | **LED transition programmes:** national initiatives. | **Cooling policy developing:** AC standards being strengthened. | **Space heating:** limited need nationally: local measures where applicable. | **Water heating:** some incentives and standards. |
| Ecuador | **Lighting:** LED programmes underway. | **Cooling:** limited formal policy. | **Space heating:** localised limited policies (Andean areas). | **Water heating:** some programmes for efficient/solar. |
| Guyana | **Lighting:** LED distribution pilots. | **Cooling:** limited policy. | **Space heating:** negligible. | **Water heating:** limited. |
| Paraguay | **Lighting:** LED replacements programmes exist but limited reach. | **Cooling:** limited policy presence. | **Space heating:** minimal. | **Water heating:** limited policy. |
| Peru | **LED promotion & subsidies** ongoing. | **Cooling:** standards in development. | **Space heating** limited (highland needs). | **Water heating:** programme for solar thermal and efficient systems (pilot/scale). |
| Suriname | **Lighting:** some LED promotion. | **Cooling:** limited. | **Space heating:** negligible. | **Water heating:** limited. |
| Uruguay | **Lighting:** LED programmes (national). | **Cooling:** standards limited but market smaller. | **Space heating:** limited. | **Water heating:** programs for efficient water systems. |
| The Bolivarian Republic of Venezuela | **Lighting:** LED programmes limited in scope. | **Cooling:** limited formal policy. | **Space heating:**zminimal. | **Water heating:** limited. |

**Notes:** AC = air conditioning; EE= energy efficiency; G20 = group of twenty; IDB = Inter-American Development Bank; INMETRO = Instituto Nacional de Metrologia, Qualidade e Tecnologia; LED = light emitting diode; LPG = liquefied petroleum gas; MEPS = minimum energy performance standards.

# 05

# ENERGY TRANSITION PATHWAYS: **POWER SECTOR**

## INSIGHTS AND RECOMMENDATIONS FOR THE ENERGY TRANSITION OF THE POWER SECTOR

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ South America's power sector, while already highly renewable and low carbon, needs to grow rapidly while further decarbonising. The DES would cut emissions by over 95% by 2050, far beyond current plans. | ★ Accelerate decarbonisation with regional targets, phasing out coal and oil while promoting renewables and resilience. |
| ★ Renewables already account for around 80% of power generation in 2023, rising to over 98% by 2050 under the DES. Solar and wind will drive most of this growth. | ★ Raise renewable targets, prioritising wind and solar integration in high-resource areas. |
| ★ Hydropower remains key, while solar PV (927 GW) and wind (427 GW) expand sharply under the DES by 2050, led by Argentina, Brazil and Chile. | ★ Fast-track deployment by leveraging natural resource advantages, scaling domestic manufacturing and streamlining permitting and grid connection procedures. |
| ★ Large-scale transmission and regional interconnectors are critical enablers of the energy transition. Without them, renewables integration and trade could face major bottlenecks. | ★ Identify, finance and fast-track regional backbone projects with regional and multilateral support. Modernise grids and enhance regional interconnections to reduce system costs, strengthen reliability and improve resilience.. |
| ★ Storage and flexibility (pumped hydro, batteries, flexible hydropower) are essential for integrating a high share of variable renewables. | ★ Set storage capacity targets, prioritise investment in batteries, establish regional market mechanisms that reward flexibility and ancillary services. |
| ★ Regional integration lowers costs, enhances energy security and accelerates the transition. | ★ Harmonise market rules, establish a regional power market with common auction mechanisms and strengthen co-ordinated grid planning. Expand cross-border and rural electrification, suported by concessional finance for infrastructure upgrades. |
| ★ Electricity demand is projected to quadruple by 2050 under the DES, driven by electrification of transport, buildings and industry. | ★ Align system planning with demand forecasts, electrification strategies and smart load management. Address emerging unplanned demand clusters (*e.g.* data centres and industrial hubs) through localisation strategies, digitalisation, and smart demand tools to ensure system stability. |
| ★ No single solution can meet future energy needs. Hydropower, regional interconnection, reserve capacity and distributed energy systems all have distinct roles in balancing supply and demand. | ★ Adopt a portfolio approach combining diversification, flexibility, and regional co-operation. |
| ★ South America will need approximately 1 355 GW of solar and wind capacity by 2050, creating significant opportunities to lead in clean energy supply chains. | ★ Develop regional supply chains for solar and wind manufacturing, logistics, and servicing to strengthen resilience and create high-quality jobs. |
| ★ Distributed energy systems and rural electrification are vital for achieving universal energy access and ensuring equity. | ★ Support distributed generation and access programmes through clear regulation, dedicated financing and innovative business models that empower local communities and enhance energy security. |

## 5.1 OVERVIEW OF THE POWER SECTOR IN THE REGION TODAY

South America's power sector underpins the region's economies and daily life, supplying electricity to nearly 440 million people in 2024 (United Nations, 2024). Installed capacity reached around 431 GW (IRENA, 2025c), while peak demand stood at an estimated cumulative peak of 190 GW. By 2050, electricity needs are expected to increase substantially, with both total capacity and peak demand projected to double.

The regional generation mix is diverse but uneven across countries. Hydropower remains the backbone, accounting for 57% of generation in 2023, followed by natural gas (14%), oil (3%), nuclear (2%) and coal (2%) (IRENA, 2025c). Wind and solar together contributed 16%, while bioenergy and other renewables supplied the remainder (IRENA, 2025c). Although the share of renewables in electricity generation (around 80%) is higher than the global average, fossil-based generation continues to provide a significant share of system reliability. Several South American countries have achieved annual renewable energy shares exceeding 60%, thanks largely to hydropower. Over the years, these countries have faced major challenges, including energy shortages, and have developed valuable experience in managing the variability inherent to renewable energy sources.

Given the variability of hydro resources, particularly under El Niño and La Niña conditions (IRENA and WMO, 2025), many hydro-dependent countries in South America have experienced severe droughts, highlighting the critical need for more diversified supply mixes. Interconnection between national grids can be a useful tool in this regard but is still limited, with only 10 GW of cross-border capacity available across the region. Enhanced regional integration could reduce costs, balance variability and strengthen resilience, but progress remains slow due to regulatory, financial and institutional barriers (Paredes, 2017).

Countries are pursuing measures to modernise their power systems, including renewable auctions, distributed generation policies, and efficiency programmes to reduce transmission and distribution losses (currently around 20%), as well as early-stage pilots in storage and flexibility. Argentina, Brazil, Chile and Colombia account for the majority of demand and capacity, although smaller countries are also advancing innovative regulations and business models.

### Initiatives and supportive policies in favour of renewable energy deployment and integration in the power sector

**Advancement of regional power sector integration**

South America is currently pursuing greater regional integration in its power sector through three major subregional initiatives. These are ARCONORTE, linking Guyana, Suriname, French Guiana and Brazil; SIESUR, which brings together Argentina, Brazil, Chile, Paraguay and Uruguay; and SINEA, involving the Plurinational State of Bolivia, Chile, Colombia, Ecuador and Peru. An additional key project is the Colombia-Panama Interconnection. Though it connects South America to Central America, this initiative is advanced in its readiness and serves as a significant model for future intercontinental power integration.

Alongside these efforts, discussions are ongoing around the creation of a fully integrated South American electricity market, drawing on the example of the Central American Regional Electricity Market, which successfully enables power trade among six Central American countries through the Central American Electrical Interconnection System interconnection system.

Regional organisations such as the Ibero-American Association of Energy Regulatory Entities, Regional Energy Integration Commission, OLADE and the IDB, together with national energy regulators, are playing a central role in strengthening the technical, regulatory, institutional and financial foundations needed to move this vision forward.

**Key question and analytical basis for the regional power sector analysis**

This study aims to address two central questions:

- What combination of measures can deliver a cost-effective, reliable and fully decarbonised power sector in the region by 2050?
- How can regional co-operation benefit and accelerate this transition?

The analysis builds on official government documents, national energy plans and long-term strategy papers, complemented by data from regional institutions and international sources. These inputs form the basis for the PES, TES and DES, ensuring that the modelling reflects the most up-to-date policy commitments, resource assessments and infrastructure plans provided by national authorities.

**Rationale and scenario framework**

The rationale for the power sector scenarios is to explore the evolution of generation, capacity and trade under different policy and technology conditions. The PES reflects the continuation of current national policies and planned projects, while the DES incorporates additional measures consistent with a 1.5°C-aligned pathway. The TES represents a middle path and is a scenario with ambition between that of the PES and DES. This approach allows for a direct comparison between existing trajectories and the enhanced actions required to meet deeper decarbonisation goals.

**"What-if" scenario design**

To test the robustness of the DES and explore potential factors affecting the transition, five complementary "what-if" scenarios were developed:

1. **DES-Hydro+** – Expand sustainable hydropower potential to strengthen clean capacity. Allow model to unlock up to 132 GW of capacity (compared to 31 GW in the DES) in large-hydropower projects in 2040-2050 (not in expansion plans).
2. **DES-Hydro+IC** – Add regional interconnection to improve balancing and optimise resource use. Add an extra 30 GW of transmission expansion candidates for 2040-2050 (coupled with large hydropower and binational projects).
3. **DES-Hydro+IC+GasLow** – Assess the effect of sustained low gas prices on the system mix and trade flows when increased hydropower interconnection capacity is considered in the expansion.
4. **DES-R** – Co-ordinate capacity reserves region-wide to reduce reserve requirements and overcapacity. Add capacity interchange of up to 30 GW to retain a 15% capacity margin in the region.
5. **DES-DER** – Expand distributed energy resources (DERs) with reduced interconnection growth, emphasising local supply. Assess local resources and distributed generation (DG) as options to resolve possible transmission stalemates. Expansion plans include optimistic DG targets of 62 GW (minimum). Reduced transmission expansion is internal and reserved for planning only.

Together, these scenarios provide a structured framework for assessing how different enabling measures (alone or in combination) affect total system costs, capacity needs, trade dependencies and the resilience of a high-renewable power system by mid-century.

**Current planning and the PES**

Across South America, most countries have embedded renewable energy expansion and power sector transformation in national plans and policies, though the scope and detail vary significantly. Brazil's ten-Year Energy Expansion Plan outlines substantial additions of solar and wind capacity to 2031, complemented by smart grid initiatives and a national hydrogen strategy (Empresa de Pesquisa Energética (EPE) and Ministério de Minas e Energia (MME), 2022). Chile's energy planning stands out with clear coal phaseout deadlines, deep renewable penetration goals and system-wide electrification commitments (Ministerio de Energía de Chile, 2015, 2020). Uruguay and Paraguay maintain nearly 100% renewable power mixes, while continuing to prioritise regional integration (International Renewable Energy Agency (IRENA), 2021; Ministerio de Industria, 2010; Ministerio de Obras Públicas y Comunicaciones (MOPC), 2021; Suaquita, 2016).

Argentina, Colombia and Peru and have developed long-term energy strategies featuring increasing roles for wind and solar, although fossil fuels continue to play a role in the system (Ministerio de Energía y Minas (MINEM), 2023; Secretaría de Energía de la República Argentina, 2023; Unidad de Planeación Minero Energética (UPME), 2020). Peru's National Energy Plan and Argentina's Energy Transition Plan outline targets extending to 2030 and 2040, reflecting incremental increases in renewables share and rural electrification targets. Ecuador's National Energy Efficiency Plan sets a 60% renewables share by 2030 with continued reliance on hydropower, although planning is relatively modest beyond that (Ministerio de Energía y Recursos Naturales No Renovables, 2017). The Plurinational State of Bolivia's Energy Agenda 2025 (Agenda Energética 2025) focuses on expanding hydropower and solar to reach 6.3 GW of capacity by 2025 but lacks a defined pathway to 2050 (Ministerio de Hidrocarburos y Energías, 2014). This document is old, however, and these targets, set in 2014, might be difficult to achieve by the end of 2025.

Meanwhile, the Bolivarian Republic of Venezuela's Homeland Plan (*Plan de la Patria*) relies mainly on hydropower with limited evidence of renewable diversification (Gobierno de la República Bolivariana de Venezuela, 2019). Guyana's Low Carbon Development Strategy seeks to significantly increase renewable electricity by 2030, supported by hydropower and solar projects (Government of Guyana, 2022). Paraguay's energy policy is built around its near-complete hydro share, with exports and regional integration central to its strategy. Suriname's energy policy prioritises rural electrification and off-grid solar in remote areas (CCREEE, 2024). Uruguay continues to strengthen its over 90% renewable electricity mix and regional integration, without plans for new fossil generation.

As reflected in the PES, the region's electricity sector trajectory is framed by growing renewable integration; continued hydropower dominance; modest fossil fuel displacement; and emerging attention to storage, digitalisation and interconnection. Yet, there remains a gap between high-level ambition and binding implementation mechanisms, particularly beyond 2030.

So far, the region has achieved significant progress in deploying renewables. In the last two decades, South America has seen wind and solar capacity grow, reaching around 113 GW in 2024, while hydropower continues to provide the backbone of electricity supply. Brazil alone installed more than 33 GW of wind and 53 GW of solar by 2024, while Chile has more than doubled its renewable capacity since 2015 through auctions and fiscal incentives. Uruguay has consolidated one of the world's cleanest electricity systems, and Colombia held its first renewable auctions in 2019 and 2021, securing a combined total of over 2 GW of new projects (Rangel, 2024; Uruguay Ministry of Industry, Energy and Mining *et al.*, 2024; U.S. International Trade Administration, 2021; Vega-Araújo and Stockholm Environment Institute, 2025). Guyana's first utility-scale solar farms are now under construction, and Peru has expanded impactful rural electrification programmes (HypaVybz, 2025; Inter-American Development Bank, 2024; IEA, 2025b; World Bank, 2019). These achievements were made possible through targeted incentive policies, including fiscal benefits, competitive tenders and sector reforms that created the conditions for private investment.

### Fiscal policies

In addition to national planning instruments and sector reforms, fiscal measures have been a central lever for governments in South America to encourage renewable energy deployment. These policies directly influence affordability and investment decisions by shaping the cost structure of technologies and projects. Fiscal policies such as tax incentives, customs exemptions and capital allowances have been implemented in at least nine countries in the region. VAT incentives are in force in Argentina, Brazil (for distributed generation), Chile, Colombia (solar panels, controllers and inverters), Ecuador and Uruguay. Import tax benefits exist in Argentina, the Plurinational State of Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay and Uruguay. Some accelerated depreciation benefits are in place in countries such as Brazil (for northeast projects) and Peru (BNEF, 2024b; IEA, n.d.b).

### Auctions

Argentina, Brazil and Colombia have auction mechanisms in place for generation or transmission. In Brazil, auctions are used as the primary method for contracting long-term energy in the Regulated Contracting Environment. Power purchase agreements from these auctions provide winners with long-term funding and favourable credit conditions from public institutions like BNDES (IRENA and BNDES, 2024). This setup is vital for project finance and reducing risks for developers, leading to over 70.3 GW of renewable energy contracts. In Brazil, wind energy accounts for 20 GW, solar PV for 5.6 GW, other renewables for 8.7 GW (including biogas and agricultural waste) and hydroelectric plants for approximately 36 GW with concessions extending up to 30 years. Since the country's first auction in 2005, the share of renewable sources has grown significantly (Table 5.1).

Auctions also play an important role in renewable capacity increase in Argentina, Colombia (Decree 570 of 2018 until 2023), Ecuador, Peru (Legislative Decree No. 1002/2008) and Uruguay. Overall, auctions in the region have resulted in over 50.6 GW of renewable energy capacity awarded since 2007 (Table 5.1).

**Table 5.1** Auction results in South America, 2007-2024

| COUNTRY | RENEWABLE ENERGY CAPACITY AWARDED THROUGH AUCTIONS (MW) |
|---|---|
| Argentina | 5 361 |
| Brazil | 34 071 |
| Chile | 7 051 |
| Colombia | 2 162 |
| Ecuador | 325 |
| Peru | 1 460 |
| Uruguay | 199 |

**Source:** (BNEF, 2025c).

**Note:** MW = megawatt.

### 5.1.1 Renewable potential and development of emerging technologies in the region

South America[42] is richly endowed with renewable energy resources, offering a strong foundation for a sustainable and diversified power system. These resources lead the region to have some of the most competitive renewables costs in the world as well.

Recent renewable energy auctions in South America have consistently demonstrated the cost-competitiveness of the region's resources, with solar and wind projects awarded at some of the lowest prices worldwide in recent years (see Chapter 1). Brazil and Colombia, for example, have secured gigawatts of new capacity through competitive rounds (Bnamericas, 2025; Enerdata, 2025). These outcomes underline how favourable resource endowments, transparent auction frameworks and economies of scale are translating into lower generation costs. Overall, South America's renewable energy potential is several times larger than the region's electricity consumption in 2023, offering a powerful foundation for an affordable and secure energy transition (Barbosa *et al.*, 2017).

The region benefits from exceptional solar potential, especially in the Atacama Desert of northern Chile and the highland areas of Argentina, the Plurinational State of Bolivia and Peru. Countries including Argentina, Brazil and Chile hold some of the highest solar irradiance levels in the world, suitable for both utility-scale PV and CSP technologies (Barbosa *et al.*, 2017; Bragagnolo *et al.*, 2022; Cacciuttolo *et al.*, 2024; Hernández *et al.*, 2020).

Wind energy potential is also substantial in the region, particularly in the southern plains of Argentina and the northeastern coast of Brazil. Colombia and Uruguay have well-documented high-capacity wind corridors, and several countries are beginning to assess their offshore wind potential, notably Brazil, Colombia and Uruguay (Barbosa *et al.*, 2017; Cacciuttolo *et al.*, 2024; Shadman *et al.*, 2023).

Hydropower remains a backbone of many national power systems, with Brazil, Colombia and Peru possessing vast untapped river systems. Smaller countries like Paraguay and Uruguay have already harnessed much of their hydropower potential and play a role in cross-border electricity trade. Due to the scale of hydropower in the region, several countries have renewable shares of over 60% of power generation today. However, these countries have learnt over the years, with big challenges (and energy shortages), to manage variability associated with renewable energy primary sources (AP News, 2024; IEA, 2021; Reuters, 2024a). Key to understanding the role hydropower can play in the energy transition is a need to update assessments of its potential in studies considering the evolution of environmental and social restrictions, and climate change. Equally important is modernisation of the existing hydropower fleet, much of which was built decades ago. Upgrades to turbines, control systems and digital monitoring can increase efficiency, extend plant lifetimes and enhance operational flexibility. In particular, modernised hydropower plants can provide crucial balancing services to complement growing shares of wind and solar, helping to stabilise grids while reducing reliance on fossil-based backup generation.

In the Andean countries, such as Chile, the Plurinational State of Bolivia and Peru, geothermal energy presents a significant opportunity, supported by extensive volcanic activity (Castillo-Reyes *et al.*, 2024).

Biomass resources, particularly in Argentina, Brazil and Colombia, also offer valuable renewable generation potential due to strong agricultural sectors and forestry activity, but this needs to be balanced with sustainability concerns (Canabarro *et al.*, 2023; Sampaolesi *et al.*, 2023).

[42] *Sources are based on national and international studies including IRENA (2020-2024), the World Bank, national energy agencies and resource mapping studies.*

The diversity of South America's renewable energy landscape creates a compelling case for regional co-operation and grid integration. Countries with high hydropower capacity, such as Brazil and Colombia, could support the flexible integration of solar and wind from neighbouring regions.

**Table 5.2** Estimated technical potential for several renewable power resources in South American countries

| COUNTRY | ONSHORE WIND | OFFSHORE WIND | SOLAR PV | HYDROPOWER |
|---|---|---|---|---|
| Argentina | 2 949 GW | 2 050 GW | 325 GW | 44 GW |
| The Plurinational State of Bolivia | 19 GW | - | 76 GW | 29 GW |
| Brazil | 1 478 GW | 142 GW | 900 GW | 172 GW |
| Chile | 255 GW | 332 GW | 51 GW | 16 GW |
| Colombia | 75 GW | 107 GW | 72 GW | 118 GW |
| Ecuador | 3 GW | - | 17 GW | 91 GW |
| Guyana | 4 GW | - | 6 GW | 9 GW |
| Paraguay | - | - | 43 GW | 56 GW |
| Peru | 7 GW | - | 64 GW | 70 GW |
| Suriname | 0 GW | - | 2 GW | 3 GW |
| Uruguay | 28 GW | - | 33 GW | 2 GW |
| The Bolivarian Republic of Venezuela | 428 GW | 156 GW | 81 GW | 62 GW |

**Source:** (ANDE, 2020; Consejo Nacional de Electricidad (CONELEC), 2018; Corporación Eléctrica Nacional (CORPOELEC), 2018; Empresa de Pesquisa Energética (EPE), 2021; Eurek et al., 2017; IHA, 2021; Suriname Energy Authority, 2017; UPME (Unidad de Planeación Minero Energética), 2019; Villazón and Gonzales, 2020; Betak, *et al.*, 2020; World Energy Council, 2020)

**Note:** Estimates reflect practical technical potential under physical and environmental constraints. "–" indicates unavailable or negligible resource; GW = gigawatt; PV = photovoltaic.

Offshore wind is the new technological frontier for South America's energy transition. Though it is still expensive compared to other options, developing offshore wind projects has several key benefits, such as large-scale, reliable power; reduced land use conflicts; minimised visual and noise impact; economic opportunities through job creation and supply chain development; and environmental benefits that contribute to reducing GHG emissions. Furthermore, offshore wind can help revitalise supply chains in Brazil, where underutilised capacity has been a challenge (IRENA, 2021a; Ministry of Energy and Mines, 2020).

The region's combination of long coastlines and favourable wind conditions positions it strongly for offshore wind development, although it is still in its early stages. However, larger investments and the establishment of adequate legal frameworks are necessary to fully realise this potential (ABEEólica, n.d.). Global organisations such as the Global Offshore Wind Alliance (GOWA) aim to incentivise and scale up offshore wind development to meet global climate goals and drive economic growth while ensuring sustainable practices. Brazil and Colombia are members of GOWA, which was established at COP27 in 2022 by the government of Denmark, IRENA and the Global Wind Energy Council. As a multi-stakeholder, diplomatic initiative, GOWA's vision is a world in which offshore wind makes a significant contribution to the energy transition and the achievement of SDGs through large-scale renewable power generation, benefiting regions, countries, and critical sectors such as industry and transportation (IRENA, 2022b).

## 5.2 ROADMAPS FOR THE POWER SECTOR TRANSITION

### 5.2.1 South America's Power sector Roadmap Summary

South America's power sector is set for major change, driven by electrification and renewables. Under the PES, transforming energy scenario (TES) and DES (Table 5.3), renewable capacity rises from 312 GW in 2024 to around 820 GW, 1 050 GW and 1 690 GW by 2050, respectively, representing 78%, 79% and 86% of installed capacity. VREs expand from almost 26% of capacity in 2024 to 57% in the PES, 59% in the TES and around 70% in the DES by 2050.

Solar leads the growth, increasing from 68 GW in 2024 to 927 GW in the DES by 2050. Wind grows from 45 GW in 2024 to 427 GW, while hydropower rises more slowly from 178 GW in 2024 to 246 GW, its share falling as solar and wind rise. Electricity generation more than doubles to 2 660 TWh in the PES and quadruple to 5 060 TWh in the DES by 2050, with renewables providing over 90% and nearly 100%, respectively, with a combination of mostly hydropower, wind and solar power.

End-use electrification underpins this shift. In the DES, electricity's share in industry climbs from 19% to 30% by 2050, in buildings from 51% to 92%, and in transport from near zero to 45%. Green hydrogen also scales rapidly, leading to a rapidly rising demand for renewable power. Production of green hydrogen reaches 22 Mt annually by 2050, requiring power generation of around 1 300 TWh to support the decarbonisation of hard-to-decarbonise sectors and exports of green hydrogen and its derivatives.

Alongside these trends, it will be crucial to expand the total amount of flexible capacity required to provide the system services needed to support such high shares of solar and wind. This includes ensuring adequate investment in storage and flexible dispatchable capacity, which can deliver essential functions such as inertia, voltage and frequency control; ramping capability; and seasonal balancing – thereby safeguarding reliability in a deeply decarbonised system. As part of a flexibility portfolio, battery storage grows from around 1 GW in 2024 to around 210 GW in 2050, while natural gas generation capacity rises from 74 GW to 260 GW (despite generating less and less over the horizon).

Delivering this transition will require strong and consistent policy support, large-scale investment in grids and storage, and deeper regional integration. Total cumulative power sector investments could reach between USD 3 trillion, USD 3.8 trillion, and USD 6.7 trillion by 2050 across the different scenarios. On an average annual basis, total investments are projected at about USD 78-119 billion per year between 2025-2030, rising in 2041-2050 to USD 153-371 billion per year. Investments in grids and flexibility could reach up to USD 222 billion per year by mid-century, representing the largest component of total spending. Renewable energy investments are expected to average USD 28-44 billion per year (2025-2030), and looking forward to 2041-2050, this would increase to USD 58-138 billion per year across PES, TES and DES respectively, led by solar and wind. Ensuring these investments flow at the required scale and pace will be critical for transforming South America into a clean, electrified, and globally competitive energy powerhouse by mid-century.

**Table 5.3** Power sector KPIs for achieving the PES, TES and DES, 2023-2050

| | HISTORICAL | | PLANNED ENERGY SCENARIO | | | TRANSFORMING ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2023 | 2024 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **KPI.01 RENEWABLES (POWER)** | | | | | | | | | | | |
| Total direct electricity consumption (TWh) | 1 049 | 1 068 | 1 252 | 1 704 | 2 229 | 1 249 | 1 881 | 2 692 | 1 274 | 2 077 | 3 105 |
| Total renewable capacity (GW) | 290 | 312 | 382 | 563 | 822 | 392 | 635 | 1 049 | 428 | 907 | 1 687 |
| Renewables' share in capacity (%) | 71% | 73% | 76% | 76% | 78% | 76% | 76% | 79% | 77% | 80% | 86% |
| Share of variable renewables in capacity (%) | 22% | 26% | 34% | 46% | 57% | 35% | 48% | 59% | 38% | 57% | 69% |
| Renewables' share in generation (%) | 79% | 81%[1] | 89% | 92% | 93% | 91% | 94% | 97% | 91% | 97% | 98% |
| Capacity by technology – solar PV[2] (GW) | 50 | 68 | 112 | 230 | 410 | 122 | 267 | 546 | 133 | 397 | 927 |
| Capacity by technology – wind[3] (GW) | 40 | 45 | 59 | 111 | 186 | 60 | 136 | 237 | 77 | 247 | 427 |
| Capacity by technology – hydropower[4] (GW) | 180 | 178 | 189 | 200 | 203 | 189 | 205 | 232 | 191 | 210 | 246 |
| Total annual electricity generation (TWh) | 1 242 | 1 267* | 1 486 | 2 023 | 2 659 | 1 482 | 2 229 | 3 215 | 1 672 | 3 146 | 5 059 |
| Renewable energy electricity generation (TWh/yr) | 982 | 1 026* | 1 318 | 1 854 | 2 464 | 1 342 | 2 093 | 3 107 | 1 524 | 3 057 | 4 967 |
| Industry's electricity share in TFEC (%) | 19% | 19% | 23% | 23% | 23% | 23% | 24% | 26% | 24% | 27% | 30% |
| Buildings' electricity share in TFEC (%) | 51% | 51% | 56% | 63% | 69% | 56% | 70% | 83% | 57% | 74% | 92% |
| Transport's electricity share in TFEC (%) | 0% | 0% | 1% | 2% | 4% | 1% | 8% | 18% | 1% | 15% | 45% |
| Battery storage capacity (GW) | ~1 | 1 | 10 | 29 | 57 | 8 | 39 | 93 | 10 | 72 | 207 |
| Dispatchable natural gas and other thermal flexibility capacity (GW) | 74 | 74 | 90 | 139 | 193 | 91 | 162 | 234 | 100 | 192 | 259 |
| **KPI.05 GREEN HYDROGEN AND DERIVATIVES** | | | | | | | | | | | |
| Power generation needs for green hydrogen and derivatives production (TWh) | 0 | 0 | 0 | 0 | 1 | 0 | 14 | 41 | 163 | 651 | 1 283 |

## TOTAL ANNUAL INVESTMENTS (2024 USD BILLION)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Renewable Energy** | | | **28** | **40** | **58** | **30** | **50** | **83** | **44** | **94** | **138** |
| Solar PV | | | 12 | 13 | 21 | 14 | 15 | 30 | 16 | 26 | 50 |
| Onshore Wind | | | 6 | 10 | 15 | 7 | 13 | 18 | 11 | 25 | 30 |
| Offshore Wind | | | - | - | - | - | - | - | - | 4 | 3 |
| Hydro | | | 6 | 15 | 21 | 6 | 16 | 28 | 7 | 17 | 31 |
| **Grids and flexbility** | | | **37** | **53** | **83** | **39** | **62** | **108** | **61** | **117** | **222** |
| **Total investments** | | | **78** | **104** | **153** | **82** | **126** | **206** | **119** | **228** | **371** |

**Source:** (IRENA, 2025c).

**Notes:**

1 *The generation values (TWh) and generation shares are model results and do not represent official statistics, total investments per column refers to average annual value per period, as follows: 2030 covers 2025-2030, 2040 includes 2031-2040 and 2050 corresponds to 2041-2050.*

2 *Solar PV capacity includes utility-scale and distributed resources.*

3 *Wind capacity considers onshore and offshore installations.*

4 *Hydro capacity considers large and small/mini installations excluding pumped hydro.*

KPI = key performance indicator; TWh = terrawatt hour; GW = gigawatt; PV = photovoltaic; FEC = final energy consumption.

### 5.2.2 Electricity needs in the future

South America's electricity demand is projected to grow significantly across all major sectors, driven by economic expansion, rising electrification and efforts to decarbonise energy systems. Meeting this demand will require both the replacement of ageing fossil-fuel power plants with modern, low-emission technologies, and major investment in electricity networks. This includes scaling up renewable generation (solar, wind, hydropower, geothermal, biomass), expanding transmission and distribution grids, strengthening cross-border interconnections, and deploying storage and digital grid management systems to integrate variable supply and new demand patterns. Total electricity generation needs (which include all electricity consumption, transformation and losses) are expected to increase from 1242 TWh in 2023, to 2 659 TWh in PES, to 3 215 TWh in TES and 5 059 TWh in DES by 2050.

Total electricity consumption in the transport sector is expected to increase from 4 TWh in 2023 to up to 793 TWh by 2050 under the DES. However, this growth is mitigated by biofuel and flex-fuel vehicles, which also play an important role in the transport sector, most notably in Brazil. A 200-times growth in transport electricity use reflects the anticipated widespread adoption of EVs and electrified public transport systems. Such a sharp increase will reshape the daily demand profile, create new demand peaks, and place significant strain on transmission and distribution networks, where available capacity would become increasingly constrained. Appropriate scaling of grid infrastructure and tariff design to support this expansion are important for an effective rollout of electrified transport.

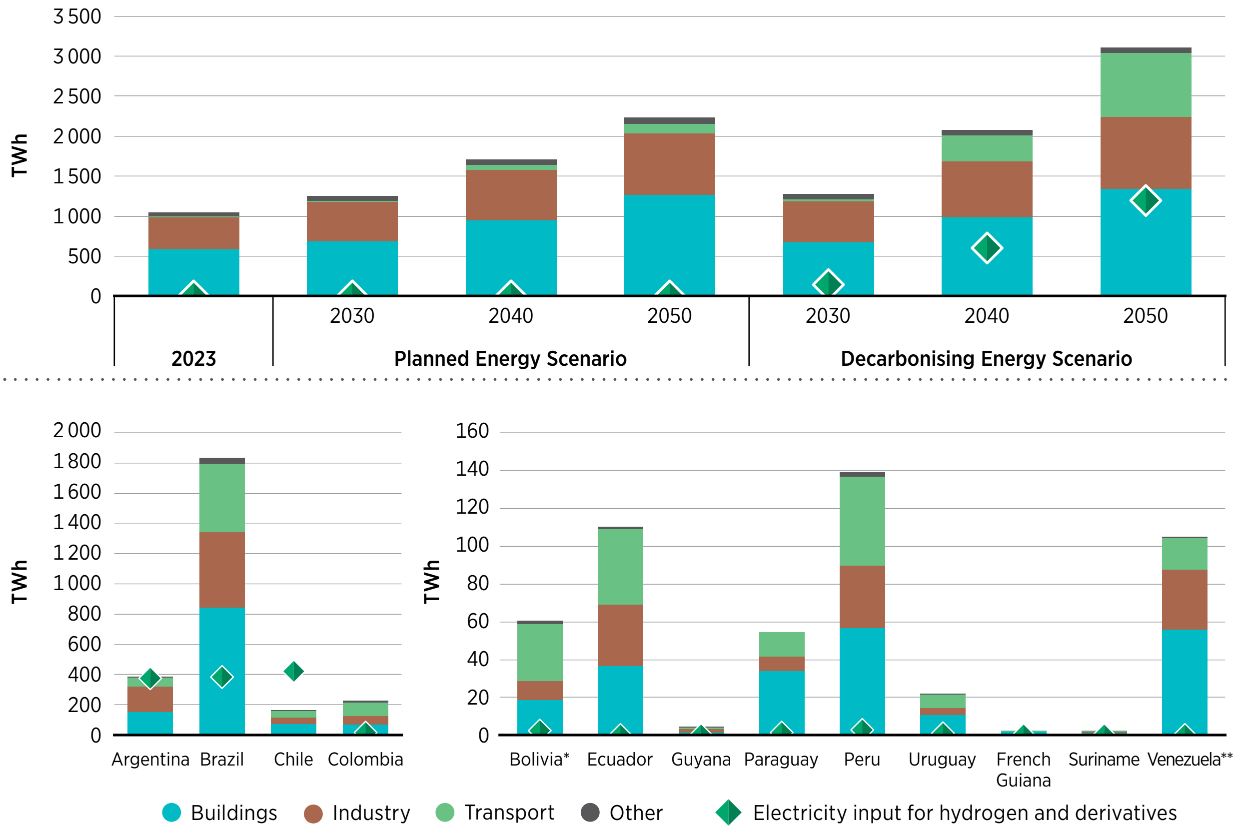
Electricity use in buildings is also set to rise steadily, from 589 TWh in 2023 to up to 1 352 TWh in 2050 under the DES. This trend is driven by the electrification of heating and cooling systems, particularly in rapidly urbanising areas, as well as the growing electricity demand from data centres and other digital equipment further electrifying the buildings sector. Seasonal variability in electricity consumption will increase due to the increased seasonality of energy service needs being met with electricity, requiring greater system flexibility and more advanced demand management tools.

Industrial electricity demand shows more moderate but sustained growth, reaching up to 890 TWh by 2050, up from 403 TWh in 2023. This reflects the gradual shift toward more electricity-intensive industrial processes, including clean manufacturing and electrified production chains.

Green hydrogen and derivatives production, currently negligible, is projected to require around 1300 TWh of electricity generation by 2050 under DES. Though this represents a small share of total demand today, it rises substantially and introduces a structurally new and highly energy-intensive load. While electrolysers generally require a minimum operating capacity factor to be economically viable, they have the potential to offer demand flexibility if supported by appropriate measures and system design. This shift carries important implications for system planning, particularly with respect to capacity adequacy and generation diversification.

Smaller categories, described as "other consumption", are expected to remain relatively stable. In 2050, demand from these uses is projected at approximately 70 TWh under the DES. While not a primary driver of growth, they remain important in meeting specific regional energy needs.

**Figure 5.1** Electricity demand in South America (TWh) under the PES and DES, by end-use sectors and for hydrogen and derivative fuels production, 2023-2050 (top), and by country under the DES by 2050 (bottom)



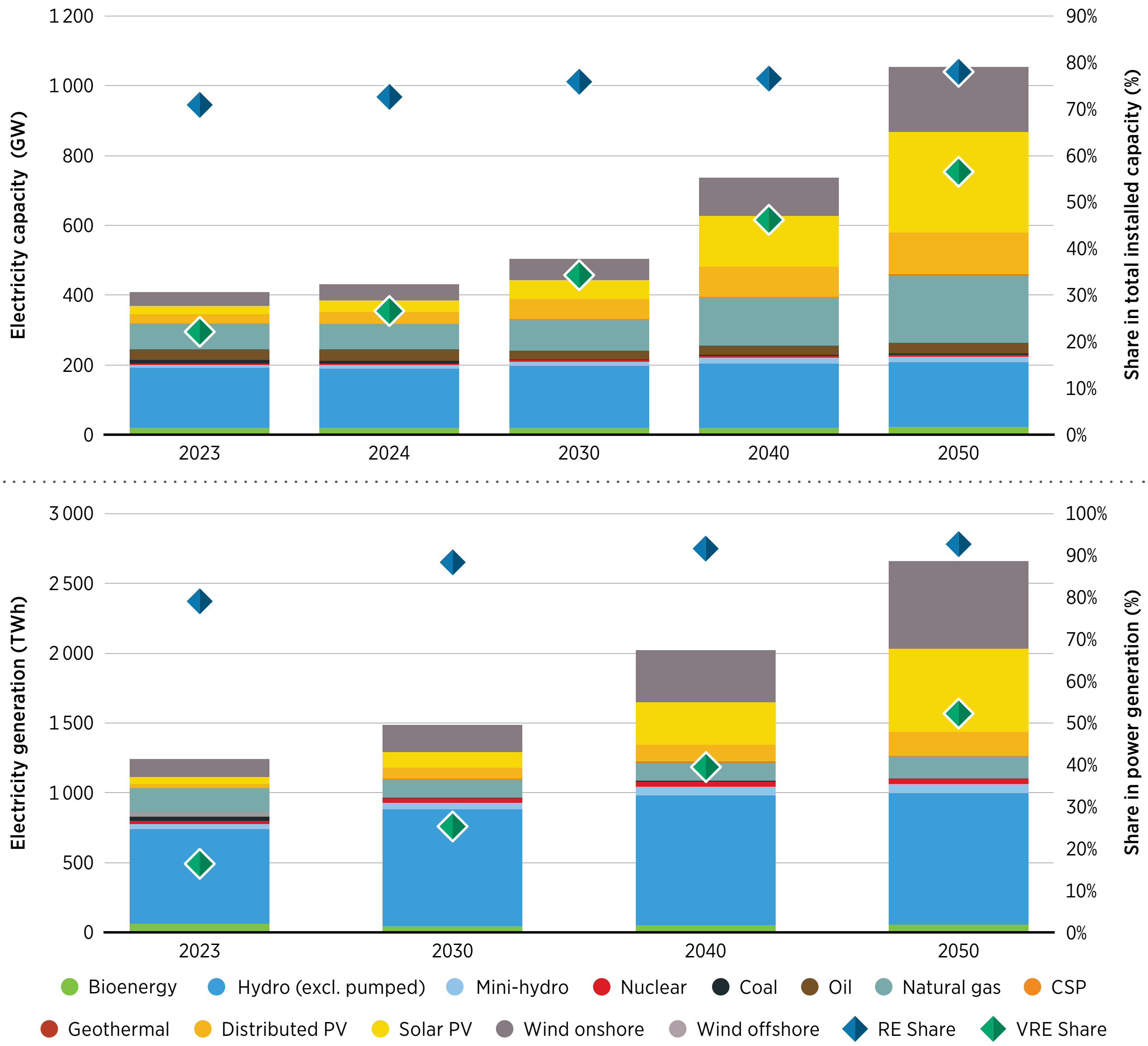

**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela; DES = Decarbonising Energy Scenario; PES = Planned Energy Scenario; TWh = terrawatt hour.

South America is well positioned to meet this rising demand, with abundant renewable resources, especially hydropower, solar and wind. However, barriers remain, including low trust levels, limited integration of energy, capacity, and ancillary services markets, constraints in grid infrastructure, uneven access to finance, and gaps in long-term planning. Overcoming these challenges will require stronger international co-operation; closer alignment between energy, environment, and finance authorities, and coherent policies that engage local communities. At the same time, the region benefits greatly from its large hydropower resources, which offer energy storage capacity, provide valuable operational flexibility, and contribute significantly to system reliability. Such measures and advantages together will be essential to ensuring a reliable, secure, and low-carbon power system by mid-century.

## 5.2.3 Where we are heading (The PES)

### Installed power generation capacity and power generation

**Figure 5.2** South America's total installed power capacity mix (GW) and power generation mix (TWh) under the PES, 2023-2050




**Source:** (IRENA, 2025c).

**Notes:** PES = Planned Energy Scenario; PV = photovoltaic; CSP = concentrated solar power; GW = gigawatt; TWh = terawatt hour; RE = renewable energy; VRE = variable renewable energy.

Under the PES, South America's power sector continues a steady but transformative shift, gradually moving away from fossil fuels and expanding its reliance on renewables, particularly solar and wind. While this scenario does not represent a full decarbonisation pathway, it still reflects a major transition in the region's electricity system. This is demonstrated by the capacity and generation projections shown in Figure 5.2 for PES. By 2050, total electricity generation is projected to more than double from 2023 levels, driven by growing demand, electrification and population growth.

Renewable energy already accounted for 73% of installed capacity in 2024 and around 80% of electricity generation in 2023 as shown in Figure 5.2. These averages hide wide differences: some countries exceed 70%, mainly from hydropower, while others, like Argentina and Chile, have much lower shares. Brazil, with about 50% of total generation and over 85% renewables, strongly shapes the regional picture. VREs, mainly solar PV and onshore wind, make up 26% of capacity in 2024 and around 16% of output in 2023. These figures rise steadily over time. By 2030, renewable capacity remains at 76%, but VREs grow to 34% of the mix. Electricity generation from renewables reaches 89%, with variable sources providing 26%. The upward trend continues through 2040, where renewables reach 76.5% of capacity and 92% of generation. VREs account for 46% of installed capacity and 39% of total generation at that time.

By 2050, the power system remains predominantly renewable, with 78% of capacity and 93% of generation coming from renewable sources. VREs reach 57% of total installed capacity and deliver more than half of all electricity. This needs a strong but carefully managed integration of wind and solar, supported by storage, grid upgrades and flexible resources.

Within the renewable mix, large hydropower (typically defined here as plants with an installed capacity above 10 MW) remains a critical pillar. Capacity increases modestly from 169 GW in 2024 to around 185 GW by 2050, with output rising from around 675 TWh to 940 TWh. Although growth is limited, hydropower continues to provide bulk, dispatchable electricity. However, the pace of new large-scale development is expected to be constrained by social and environmental considerations, including land use impacts and community opposition, which can make new project approvals challenging. Beyond this traditional role, the analysis also indicates that reservoir-based hydropower increasingly supports system flexibility, complementing solar and wind by adjusting output to cover evening and night-time demand or periods of lower renewable availability. Mini-hydro also sees gradual expansion, growing from 10 GW to 17 GW, and producing around 65 TWh by mid-century.

Solar PV scales up significantly. Capacity rises from 33 GW in 2024 to 290 GW by 2050, with generation growing from 45 TWh in 2023 to 590 TWh by 2050. Wind power sees even more substantial growth, increasing from 45 GW to 186 GW in capacity and reaching around 630 TWh in annual output, making it the single largest contributor among new renewable technologies by 2050. Alongside utility-scale growth, distributed solar and targeted rural electrification programmes remain essential to closing persistent access gaps, particularly in remote areas.

The role of fossil fuels changes significantly across the period. Coal capacity declines from 9 GW in 2024 to just 2 GW by 2050, and its generation falls to 4 TWh. Oil-fired capacity and output decrease sharply, with diesel and fuel oil contributing only marginal amounts by mid-century.

Natural gas, however, follows a more complex path. Its installed capacity grows steadily from 74 GW in 2024 to 193 GW by 2050. Despite this increase, electricity generation from gas drops, from 170 TWh in 2023 to 155 TWh in 2050. This highlights a structural shift in how gas is used. Rather than serving as a constant power source in the merit order, gas increasingly functions as a reserve and peaking resource, called upon during periods of low renewable output or high demand.

This shift is partly a response to capacity adequacy and system reserve needs where natural gas capacity plays an essential role in meeting capacity reserve requirements. As the share of VREs increases, the system must ensure reliability during periods of intermittency. Gas plants, especially open-cycle, modern combined cycle, modular and flexible units, offer fast ramping and dispatchable power that complements solar and wind. However, they are often underutilised in terms of full-load hours, operating in a backup or balancing role rather than as central contributors to generation. In other words, more capacity is installed than is frequently used, because of the need to meet peak demand or respond to shortfalls in renewable generation.

Capacity constraints, particularly the need to maintain reserve margins as traditional baseload sources retire or reduce output, also influence the expansion of gas-fired generation. Gas remains important for longer-duration and seasonal flexibility, especially in the absence of large-scale deployment of long-duration storage or regional balancing mechanisms which, if implemented, would moderate the expansion of gas capacity.

Nuclear energy also expands slightly, increasing from 4 GW to 5 GW of capacity and producing a steady approximately 40 TWh by 2050. This aligns with national plans in Argentina and Brazil and contributes a reliable, low-emission supply of electricity.

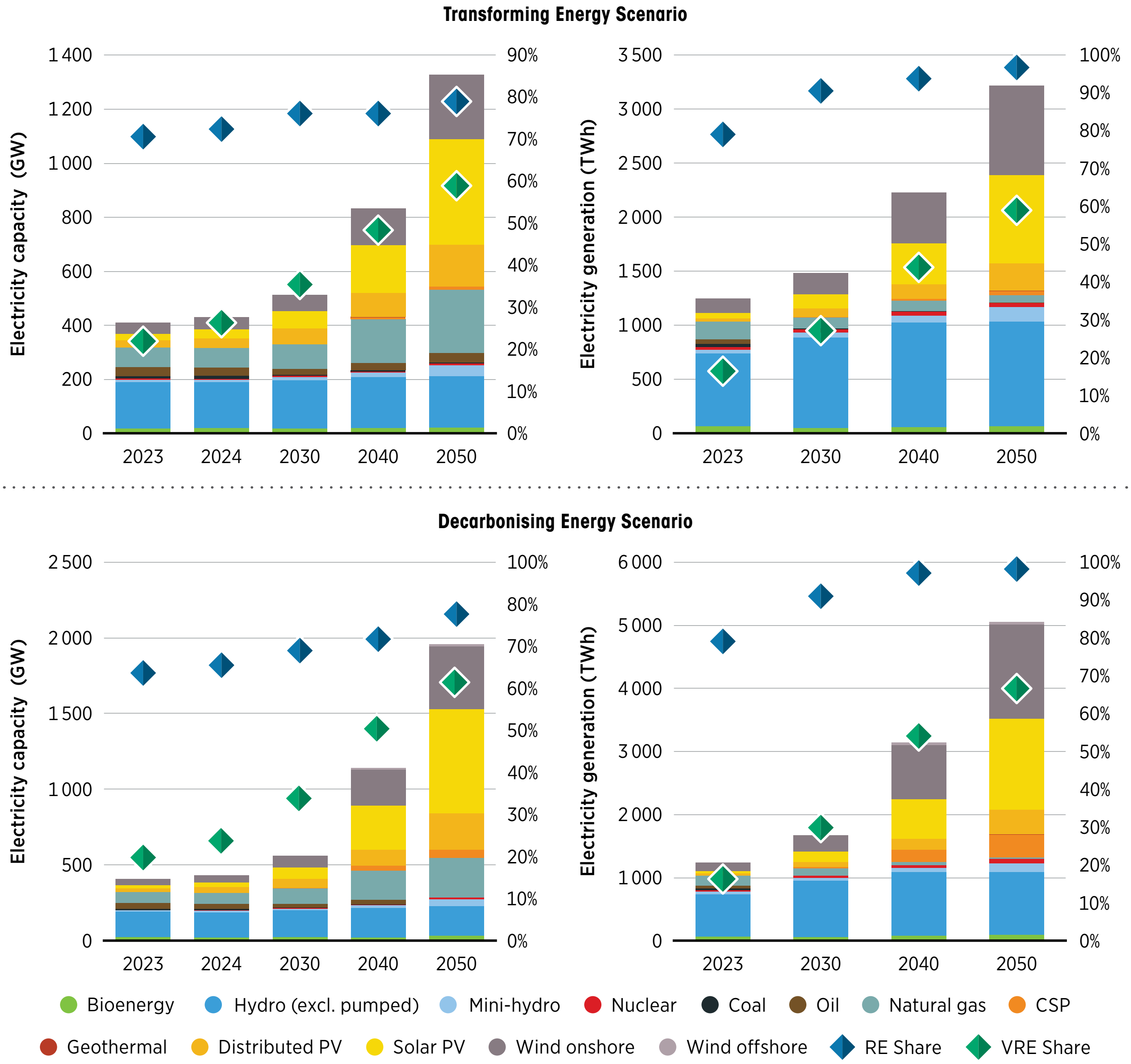
Alongside these shifts in generation, South America's transmission networks need to evolve. The expansion of solar and wind into remote, high-resource areas (such as Patagonia for wind and the Atacama Desert for solar) requires not only targeted new connections where necessary but also the optimisation and strengthening of existing grid infrastructure to reduce congestion and improve reliability. Cross-border interconnections in regions such as the Southern Cone and Andean zones could enhance flexibility and energy trade. Deeper regional co-ordination and investment in grid expansion are essential to unlocking the full value of renewables and helping ensure security of supply.

Overall, the PES outlines a moderate but forward-moving clean energy transition. Solar and wind take on a central role, supported by hydropower, storage and moderate use of gas. The role of fossil fuels changes dramatically, especially for natural gas, which becomes more about capacity assurance than energy provision. With ongoing investment in infrastructure, flexibility and regional co-operation, the region shows that a predominantly renewable power system is both technically and economically viable.

## 5.2.4 Unlocking South America's potential under the TES and DES

Building on the PES, the TES and DES outline a faster and more ambitious transformation of South America's power sector. The DES stands out particularly as it meets a fourfold increase in electricity demand by 2050, driven by hydrogen production targets, wider electrification of transport, industry and buildings. This is demonstrated by the capacity and generation projections shown in Figure 5.3 for TES and DES. While all three (PES, TES and DES) scenarios expand renewables significantly, the DES accelerates deployment, cuts fossil fuel use more sharply and embraces a broader range of clean energy technologies. The purpose of exploring the TES and DES is to highlight what additional measures would be required to align more closely with long-term climate objectives, going beyond the high renewable share already achieved in the PES. It reflects a region that is not only leveraging its natural endowments but also raising its climate ambitions.

**Figure 5.3** Total installed power capacity mix (GW) (left) and power generation mix (TWh) (right) in South America under the TES (upper) and under the DES (lower), 2023-2050




**Source:** (IRENA, 2025c).

**Notes:** CSP= concentrated solar power; DES = Decarbonising Energy Scenario; GW= gigawatt; PV = photovoltaic; RE= renewable energy; TES = Transforming Energy Scenario; TWh = terawatt hour; VRE= variable renewable energy.

The shift begins from a solid starting point. In 2024, renewables already made up around 75% of installed capacity and over 80% of electricity generation. Under the DES, these shares rise quickly. Figure 5.3 shows by 2030, renewable energy comprises 77% of capacity and nearly 91% of generation. VREs, led by solar PV and wind, grow rapidly, rising from 26% of capacity in 2024 to 38% by 2030, and doubling their share of generation to 30%. By 2040, renewables reach 80% of capacity and 97% of generation, with VRE accounting for nearly 57% of installed capacity and around 55% of generation. In the TES, 2030 values are similar to the PES and DES, but by 2040, renewables reach 76% of capacity and 94% of generation, reflecting a pathway that is more accelerated than the PES in renewable deployment but less so than the DES.

By 2050, the transformation to a climate-compatible pathway nears completion. Renewables supply 98% of all electricity and make up more than 86% of installed capacity. VRE technologies alone contribute nearly 69% of total capacity and around 67% of electricity generation. In the TES, renewables reach 79% and 97% of capacity and, generation respectively. The DES reflects a system that is more decentralised, more flexible, and almost entirely decarbonised while meeting vast growth in power demand. While the TES shows a system that is less renewable and decarbonised than DES, it is less constrained and demanding in terms of its implementation.

The scale of renewable deployment under the DES is significantly larger than in the TES and PES. Solar PV sees the most dramatic growth. Utility-scale systems reach nearly around 690 GW by 2050, supported by another approximately 240 GW of distributed generation, including rooftop systems. Together, total solar PV capacity reaches around 930 GW, a fourteenfold increase from today. Solar generation rises to nearly 1400 TWh by mid-century. Distributed systems also play a crucial role in improving electricity access in remote areas, helping close persistent rural gaps while enhancing local resilience.

Wind energy also rises sharply, growing from 45 GW in 2024 to approximately 430 GW by 2050, with generation climbing to more than 1500 TWh. The scale of growth is particularly strong in high-wind regions like Argentina's Patagonia, northeast Brazil and coastal Uruguay. Offshore wind, which reaches 12 GW in the DES, is a key policy option and alternative to onshore wind and could contribute significantly under the DES, especially along Brazil's coast, particularly if environmental concerns regarding onshore wind restrict its permitting and expansion.

Hydropower remains the region's stabilising backbone. Large hydropower grows from 169 GW in 2024 to 200 GW by 2050, with output increasing to around 1000 TWh. Mini-hydro sees much faster growth, rising from under 10 GW to nearly 47 GW of capacity, and contributing around 150 TWh. This is particularly relevant for rural electrification in mountainous zones such as the Andes, where decentralised small hydropower projects improve access and grid resilience. The Arco Norte corridor further enhances the region's hydropower outlook, providing benefits not only through optimised energy trade with Brazil, but also by unlocking substantial hydropower potential in Guyana, Suriname, and French Guiana. Results indicate that up to several GW of hydropower projects in both Guyana and French Guiana alone could be developed, offering valuable flexible energy and firm capacity to support Brazil's northern grid.

The DES also introduces a wider range of renewable and low-carbon technologies. Geothermal, while still modest, begins to scale up in The Plurinational State of Bolivia, Chile, Colombia and Ecuador, contributing around 6 TWh by 2050. Advanced distributed generation plays a growing role, with nearly 395 TWh of output, largely from rooftop solar. Solar thermal technologies, such as CSP, are likely to support dispatchable solar generation, particularly in Chile, although current capacity figures do not yet fully reflect this potential.

Fossil fuels decline steeply. Coal is completely phased out by 2050, and oil-fired power drops to negligible levels. Natural gas capacity does continue to expand (rising from 74 GW to nearly 260 GW), but its use shifts dramatically. This rise in capacity reflects its importance in meeting capacity reserve requirements in capacity expansion modelling. However, this need could also be met though deployment of a basket of other novel technologies, such as renewable gases, long-duration energy storage, advanced demand-side management and a range of other technologies.

Instead of serving a more central role in meeting daily demand, natural gas plays a sharply reduced role in electricity production, generating around 24 TWh by 2050. This drop from over 170 TWh today reflects its repositioning as a reserve and balancing asset, deployed during renewable shortfalls or extreme peak demand. Much of this gas capacity remains idle under normal conditions, retained for reliability and contingency. This underlines how growing capacity does not equate to higher generation, especially as grid flexibility and storage improve. Additional analysis performed for TES, demonstrated that any lagging in renewables expansion will impact natural gas fired power generation, which indicates that it remains an import safeguard for system operation reliability.

Biomass with CCS is expected to play a complementary role in certain countries, offering both dispatchable power and negative emissions.

Nuclear generation remains steady across the period, with 9 GW of capacity contributing around 70 TWh annually by 2050. This reflects ongoing operation and modest expansion in Argentina and Brazil, where existing nuclear programmes provide a stable base of non-variable, low-emission supply.

To make the DES viable, regional and national grid development needs to keep pace. Expanded interconnections will be critical to support balancing across borders, enabling solar-rich regions in Chile or hydro-dominant zones in Brazil and Colombia to balance the wider system. Upgrades to existing systems and new transmission routes will be needed to handle decentralised generation and new electrified loads. Within countries, internal grid investment is essential to connect remote renewable resources and to accommodate the surge in rooftop and distributed power.

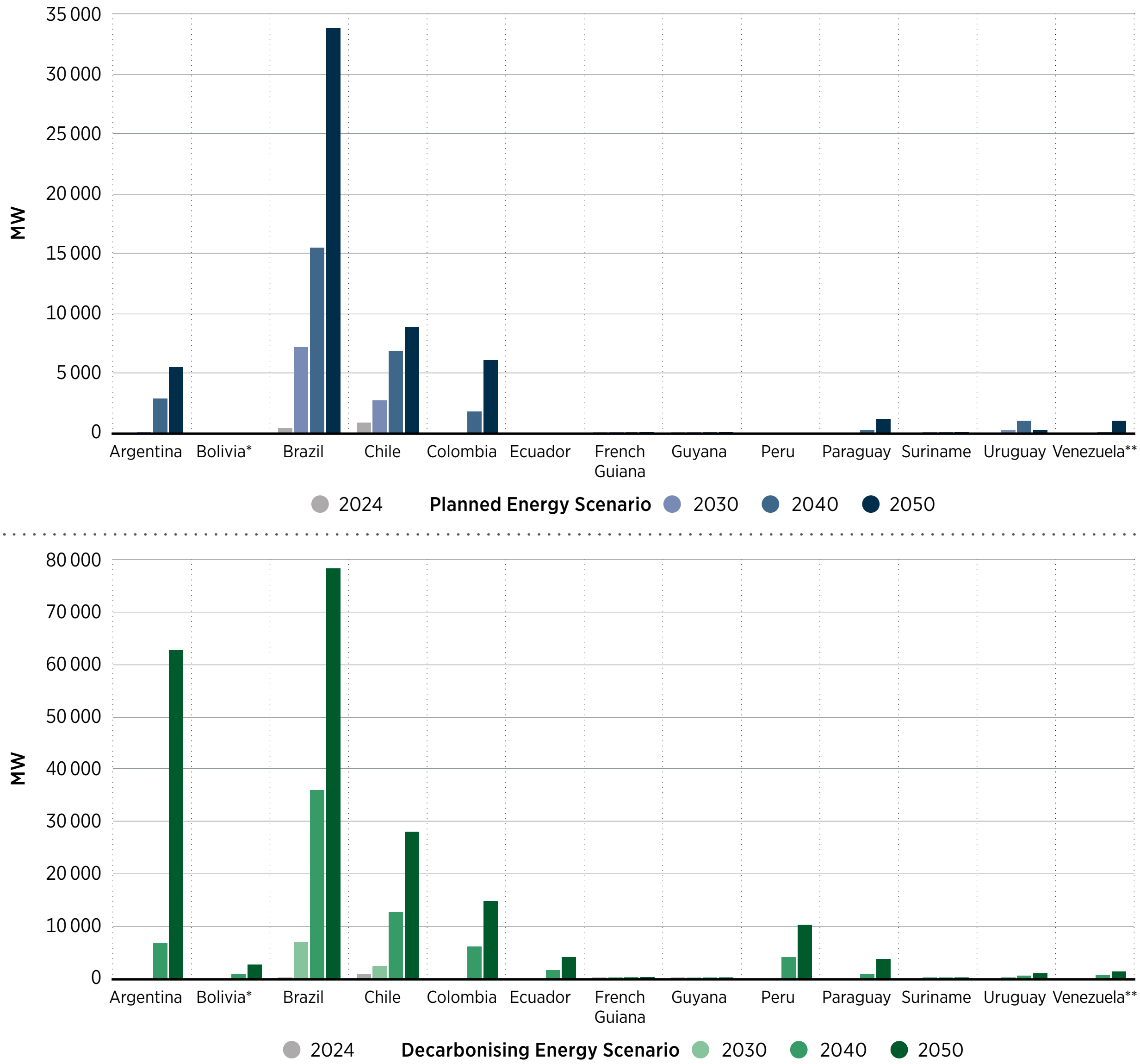
In essence, the DES shows what South America can achieve when it combines political commitment with technical innovation. By harnessing its vast renewable potential and reinforcing system-wide flexibility, the region can meet rising demand while delivering deep decarbonisation. The result is not only a cleaner power sector but a more resilient, equitable and future-proof energy system.

### 5.2.5 Transmission, storage and system flexibility

The transformation of South America's power sector will depend on infrastructure and resources that enhance system flexibility. Transmission networks, energy storage and regional integration are all critical for managing variability and ensuring system reliability as VREs rise.

Battery deployment begins from a very small base, with around 1.2 GW installed in 2024, concentrated in Brazil and Chile and mainly serving short-duration balancing and grid stability. Growth accelerates thereafter, but the scale differs across scenarios. Figure 5.4 shows by 2030, capacity rises to around 10 GW, with Brazil and Chile leading and initial systems appearing in Argentina, Guyana and Uruguay. The 2040s mark a turning point: in the PES, capacity exceeds 29 GW by 2040 and more than doubles to 57 GW by 2050, supporting peak shaving, capacity reserves and time-shifting of solar and wind. Meanwhile in the TES, it grows to 39 GW by 2040 and 93 GW by 2050. In the DES, growth is far more dramatic: storage surpasses 72 GW by 2040 and around 210 GW by 2050, with Brazil, Argentina and Chile leading large-scale rollouts. In both cases, batteries play an essential role in reducing curtailment and enabling higher shares of solar and wind in the mix.

**Figure 5.4** Battery capacity deployment in South America under the PES (top) and DES (bottom), by country, 2024-2050




**Notes:** MW = Megawatt; * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela.

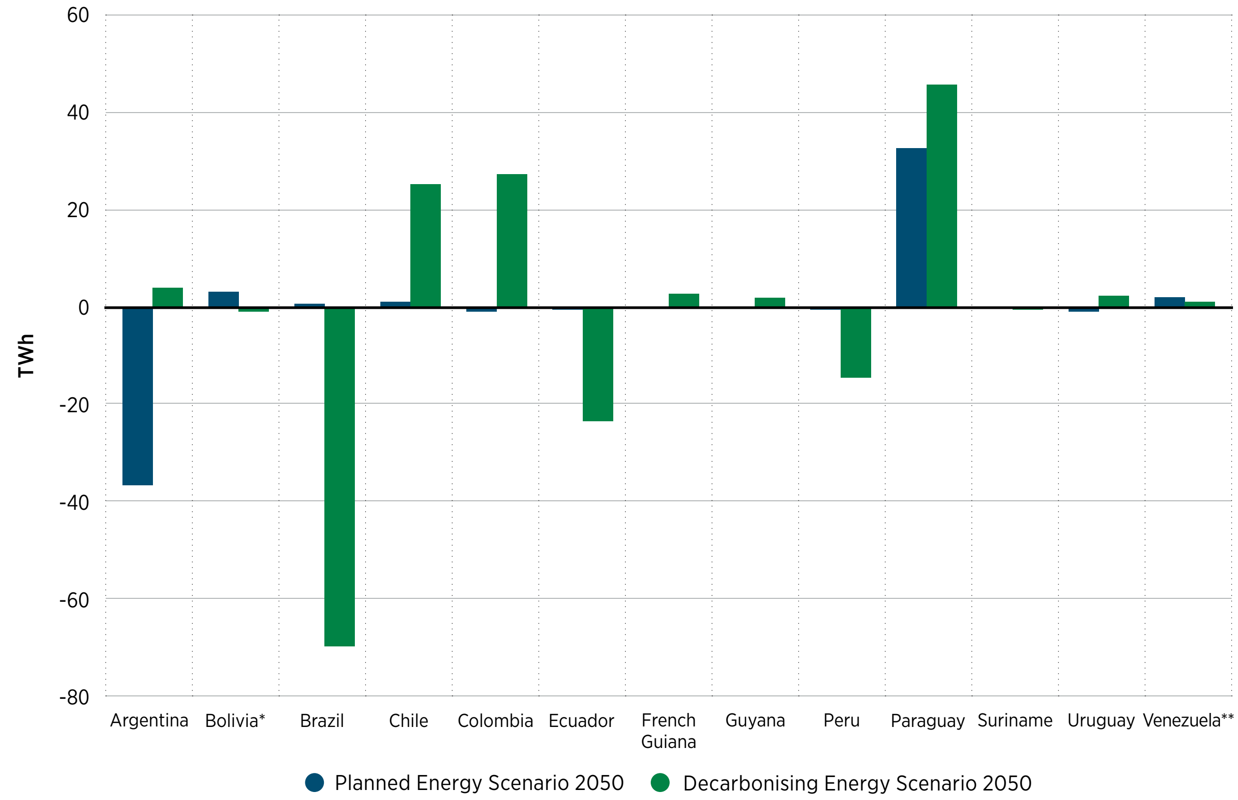

Electricity trade also evolves substantially. Today, exchanges are modest and concentrated in a few corridors: Paraguay exports firm hydropower to Brazil and Argentina; Uruguay manages two-way flows with its larger neighbours and Colombia; and Ecuador and Peru balance their hydropower resources with smaller volumes of trade.

In the PES, modelling of the whole horizon shows that net import and export flows expand only gradually. By 2050, Paraguay remains the dominant net exporter (around 33 TWh), supplying Brazil and Argentina, (as shown in Figure 5.5). Brazil's balance fluctuates, ending the period close to zero (0.6 TWh net exports), while Argentina remains a significant net importer (-37 TWh). Chile moves into small positive exports (about 1 TWh), and Colombia trends toward balance (-1 TWh). Overall, regional trade roughly doubles compared to today's levels but remains moderate in scale.

In the DES, the picture is far more dynamic and the volumes much larger by 2050 (as shown in Figure 5.5): sevenfold today's levels. By 2030, Brazil shifts briefly into net exports of around 11 TWh, sending surplus to Argentina and Peru, while Argentina's net imports climb past 40 TWh. By 2040, Brazil becomes the largest importer in the region at about 70 TWh, supplied mainly by Paraguay and Peru, while Argentina's net imports peak near 38 TWh. By 2050, flows are highly integrated: Brazil records the largest net imports (-70 TWh), while Argentina shifts to a modest net exporter (+4 TWh). Paraguay remains the anchor exporter (46 TWh), Peru records a sizeable net import position (-14 TWh), Ecuador becomes a major importer (-24 TWh) and Colombia a large net exporter (+27 TWh). Uruguay moves from net imports in the PES (-1 TWh) to net exports (+2 TWh) in the DES. These patterns highlight how hydropower, solar, wind and storage combine across borders to provide stability and cost savings at a continental scale.

The comparison of PES and DES net positions in 2050 (as shown in Figure 5.5) shows the structural shift: Brazil moves from balance in the PES to the region's largest importer in the DES (a swing of about -70 TWh), while Argentina transitions from heavy reliance on imports (-37 TWh) to slight net exports (+4 TWh). Paraguay's export role deepens (from +33 TWh to +46 TWh), while Colombia shifts from near balance (-1 TWh) to a major surplus (+27 TWh). Ecuador's position changes sharply, from -0.3 TWh to -24 TWh, reflecting increased dependence on its neighbours. Peru also deepens its net import position (from -0.1 TWh to -14 TWh). Overall, the DES reflects much greater integration, larger imbalances between countries and stronger reliance on continental-scale complementarities.

**Figure 5.5** Net exports in South America (TWh) (top) and net difference between DES and PES flows (TWh) (bottom), by country, 2050




| TWh | | EXPORTING | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Argentina | Bolivia* | Brazil | Chile | Colombia | Ecuador | French Guiana | Guyana | Peru | Paraguay | Suriname | Uruguay | Venezuela** |
| IMPORTING | Argentina | - | -3 | -6 | 10 | - | - | - | - | - | -12 | - | 0 | - |
| | Bolivia* | 3 | - | 1 | 3 | - | - | - | - | - | 0 | - | - | - |
| | Brazil | 15 | 5 | - | - | - | - | 6 | 8 | 15 | 28 | - | 0 | 0 |
| | Chile | 13 | 0 | - | - | - | - | - | - | 0 | - | - | - | - |
| | Colombia | - | - | - | - | - | -1 | - | - | - | - | - | - | -0 |
| | Ecuador | - | - | - | - | 26 | - | - | - | 3 | - | - | - | - |
| | French Guiana | - | - | 0 | - | - | - | - | - | - | - | 4 | - | - |
| | Guyana | - | - | 10 | - | - | - | - | - | - | - | 1 | - | - |
| | Peru | - | - | 1 | 25 | - | 7 | - | - | - | - | - | - | - |
| | Paraguay | 1 | 2 | -0 | - | - | - | - | - | - | - | - | - | - |
| | Suriname | - | - | - | - | - | - | 0 | 5 | - | - | - | - | - |
| | Uruguay | -3 | - | -0 | - | - | - | - | - | - | - | - | - | - |
| | Venezuela** | - | - | 0 | - | 1 | - | - | - | - | - | - | - | - |

**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela; DES = Decarbonising Energy Scenario; PES = Planned Energy Scenario; TWh = terrawatt hour.

These developments emphasise how crucial transmission expansion and regional interconnection are. New corridors are needed to link remote renewable zones in northern Chile and Argentina, southern Brazil and Uruguay, and the Andean region with demand centres and neighbouring markets. The DES highlights the scale of investment required, with priority projects grouped as follows:

- **Northern links (Brazil, French Guiana, Guyana, Suriname):** Upgrades and new connections ranging from 300-3 100 MW with investments of USD 115-315 million needed to harness hydropower and integrate with Brazil's grid.
- **Andean connections:** The Plurinational State of Bolivia–Peru (150 MW, ~USD 65 million), the Plurinational State of Bolivia–Argentina (440 MW, ~USD 70 million) and Chile–the Plurinational State of Bolivia (140-340 MW, USD 52-164 million), improving resilience and balancing across the central Andes.
- **Brazil's strategic corridors:** Brazil–the Plurinational State of Bolivia (800 MW, USD 792 million), Brazil–Paraguay (2 000 MW, USD 555 million) and Peru–Brazil (2 200 MW, USD 2.37 billion), which are central to integrating large-scale hydropower and solar resources.
- **Southern Cone integration:** Chile–Argentina links (50-717 MW, USD 104-1 769 million) to unlock solar and wind complementarities.
- **Northern Andes and Central America:** Ecuador–Colombia (1 500 MW, ~USD 211 million), Peru–Ecuador (252-1 000 MW, USD 236-401 million) and Panama–Colombia (400 MW, USD 600 million), supporting wider regional integration.

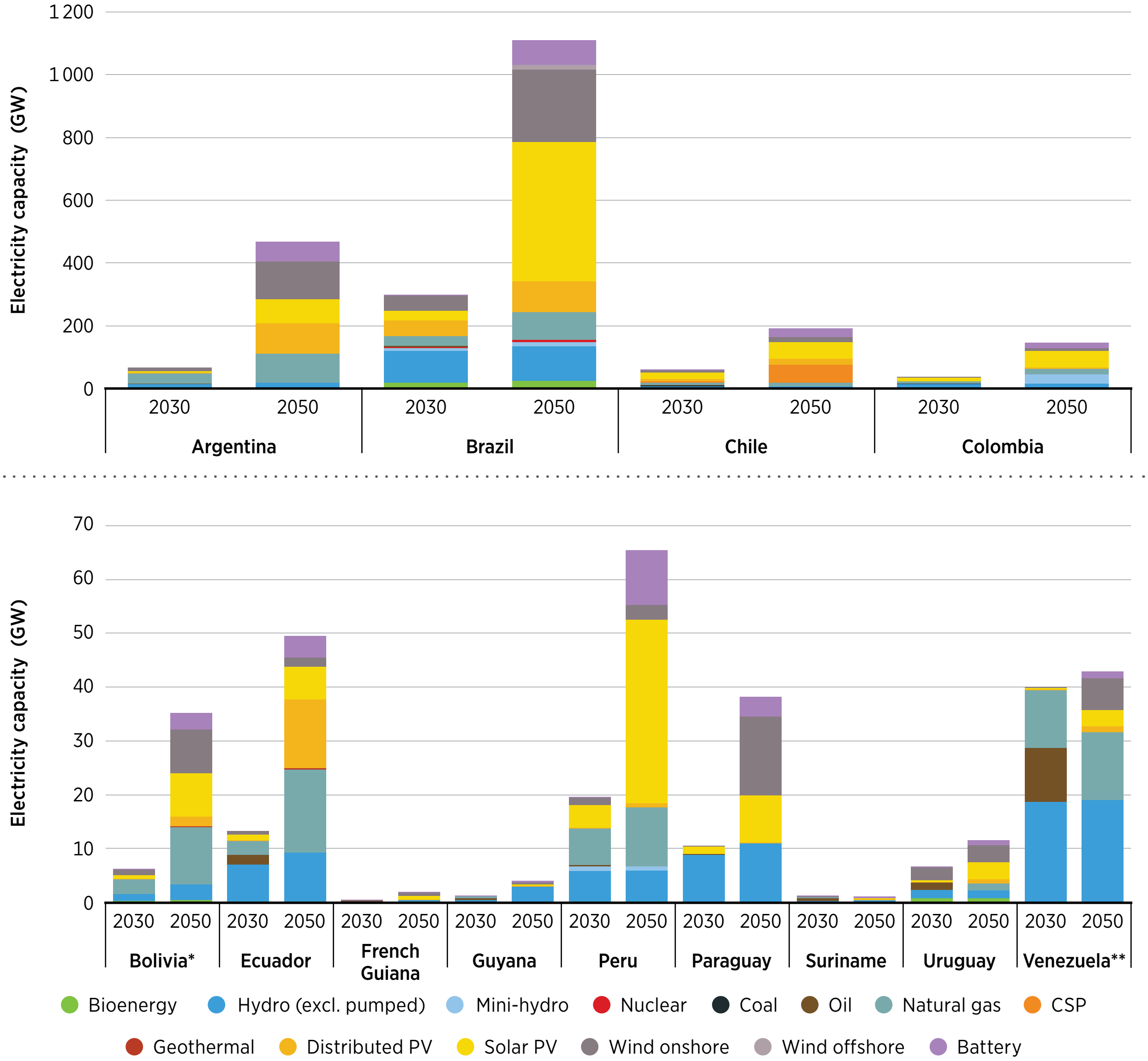
By mid-century, both scenarios envisage a power system that is more flexible, integrated and reliable. Under the PES, this evolution supports steady decarbonisation while reducing costs and improving reliability. Under the DES, the same foundations enable a fully decarbonised, highly interconnected regional grid, capable of meeting a fourfold increase in demand while maintaining resilience and stability.

### 5.2.6 Regional dimension of the power sector transformation

The DES reflects a transformation that is not only large in scale but also widely spread in its national composition. Between 2025 and 2050, South America adds around 1.4 TW of renewable capacity. How and where this expansion unfolds is unevenly distributed and the value of interconnection and resource complementarity becomes central to system design.

By 2030, total renewable installed capacity in the region grows to around 430 GW, marking a substantial early step toward decarbonisation. However, this expansion remains highly concentrated: nearly 80% of all new renewables in this period are built in Argentina, Brazil and Chile. Brazil alone reaches nearly 260 GW of renewable capacity, driven by hydropower, solar, wind and rapidly growing distributed generation. Chile's system shifts decisively toward solar, reaching over 20 GW of PV, while Argentina deploys over 18 GW of new wind and solar capacity. Other countries, such as Colombia, Ecuador and Peru, scale up more gradually, building primarily on hydropower and solar foundations. Import and export activity remains broadly in line with present-day levels.

**Figure 5.6** Total installed power capacity mix (GW) in South America under the DES, by country, 2030 and 2050




**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela; Bioenergy = includes biomass solid and biomass solid CCS; CCS = carbon capture and storage; CSP= concentrated solar power; DES = Decarbonising Energy Scenario; GW= gigawatt; PV = photovoltaic.

By 2050, renewable capacity in the region reaches approximately 1690 GW, four times the 2030 total. Brazil expands to 935 GW, Argentina exceeds 310 GW, and Chile nears 150 GW, while Colombia pass 110 GW. As discussed earlier, import and export dynamics play a key role, though for most countries this remains below 10% of power generation It is also important to note that by 2050 there are large areas and long periods that operate with very high shares of inverter-based generation, which indicates a need to plan for grid stability issues to secure system operation.

### Challenges to realising a coherent regional system

Turning this diverse expansion into a stable, integrated power system involves a number of complex and overlapping challenges. Without co-ordination and shared planning, asymmetries in capacity, governance and investment can undermine system performance and fairness. Several structural challenges need to be addressed if South America is to move from national energy transitions to a coherent, regionally integrated system. These include:

- **Infrastructure misalignment**: Many countries have ambitious renewable targets, but investment in transmission (internal and international), smart grids and storage is lagging. Without upgrades, congestion and curtailment risks will increase.
- **Planning fragmentation**: Electricity sector plans are not always consistent across agencies or borders. Disparate assumptions for demand, storage and generation capacity reduce investment certainty and system coherence.
- **Grid code and technical standard mismatches**: Operational rules for renewable integration, frequency management and inverter response are not harmonised, making cross-border exchanges and service sharing difficult.
- **Lack of markets for system services**: Ancillary services such as inertia, voltage support and frequency control are often still bundled with conventional generation. Without clear markets, clean technologies that can provide these services remain underutilised.
- **Slow and unclear permitting**: Renewable projects, particularly wind, hydropower and storage, face delays due to unclear permitting pathways, overlapping jurisdiction or land use conflicts.
- **Institutional capacity gaps**: Especially in smaller systems, technical and regulatory institutions may lack the capacity or autonomy to lead on system flexibility, service procurement or project integration.
- **Governance, shared vision and social licence:** Regional integration also depends on a shared vision and mechanisms to recognise projects of common interest, decisions on who invests and how benefits are shared. A common framework for consultation, benefit-sharing and dispute resolution would reduce risk, align expectations across borders and accelerate delivery.
- **Supply chain vulnerabilities:** Many of the technologies needed for the transition are imported, and current global supply bottlenecks—where vendors tend to prioritise developed markets—could slow both the speed and scale of deployment across the region. Strengthening local supply chains and diversifying import sources will be key to mitigating these risks.

These challenges will need to be tackled systematically, or the energy transition could fragment into parallel, unco-ordinated national efforts that could risk undermining both economic efficiency and energy security.

At the same time, the scenario offers clear opportunities for green industrialisation. The scale and pace of renewable energy expansion, especially solar and wind, enable new value chains in green hydrogen, clean fuels (both potential alternatives in the DES for natural gas reliance), low-carbon metals and battery supply. Countries such as Argentina, Chile and Brazil are especially well positioned to develop renewable-powered export hubs and clean industry clusters. These developments can boost GDP, create jobs and make the energy transition a growth agenda, not just an environmental one.

Natural gas also retains a transitional role along the horizon, but in a different way. While total gas capacity expands under the DES to nearly 260 GW by 2050, its role in generation collapses: from over 170 TWh today to only 24 TWh in 2050. This reflects a shift from energy provision to strategic reserve and contingency use, ensuring reliability in times of extreme demand or renewable shortfall. Even under the DES, it remains an important part of system operation and security. Importantly, CCS plays no meaningful role, suggesting a clear preference for reducing fossil fuel use altogether rather than prolonging it through retrofitting.

Given the vast expansion of onshore wind in DES on a cost basis, offshore wind could become more attractive should environmental concerns raise local opposition to its expansion. South Americas total of 415 GW of onshore wind in the DES is equivalent to 100 000,5-MW turbines each of which is 200 metres tall and would be widely dispersed over an area approximately of 115 000 $km^2$, under typical spacing. Offshore wind would reduce these levels. Despite strong technical potential (particularly along the coasts of Brazil, Argentina, and Colombia) offshore wind's high capital costs, fixed operational costs, longer lead times, and infrastructure demands make it less competitive than the continent's abundant onshore solar and wind resources.

## 5.2.7 What if scenario analysis

Following the analysis of demand and supply evolution under the PES, TES and DES, this section explores five complementary "what-if" scenarios. Rather than building sequentially, they test the robustness of the DES and quantify the benefits of unlocking resources and enablers currently in a "stand-by" state in the scenario.

- **DES-Hydro+** allows for expansion of additional sustainable hydropower, adding a potential deployment of 132 GW of large projects in Brazil, Peru and Argentina.
- **DES-Hydro+IC** introduces an extra 30 GW of regional interconnection candidates, strengthening system balancing and binational co-operation.
- **DES-Hydro+IC+GasLow** assesses how sustained low gas prices under deeper integration could alter the generation mix and trade flows.
- **DES-R** explores co-ordinated regional capacity reserves, enabling up to 30 GW of capacity exchange to maintain a 15% margin.
- **DES-DER** examines slower transmission growth, testing whether 62 GW of distributed energy resources could sustain progress toward net zero.

Together, these scenarios aim to reveal the flexibility, resilience and trade-offs within the DES pathway, showing how different combinations of regional integration, technology deployment and market co-ordination could strengthen the region's ability to deliver a secure, affordable and low-carbon power system.

**Table 5.4** Comparison of what-if scenarios for the power sector

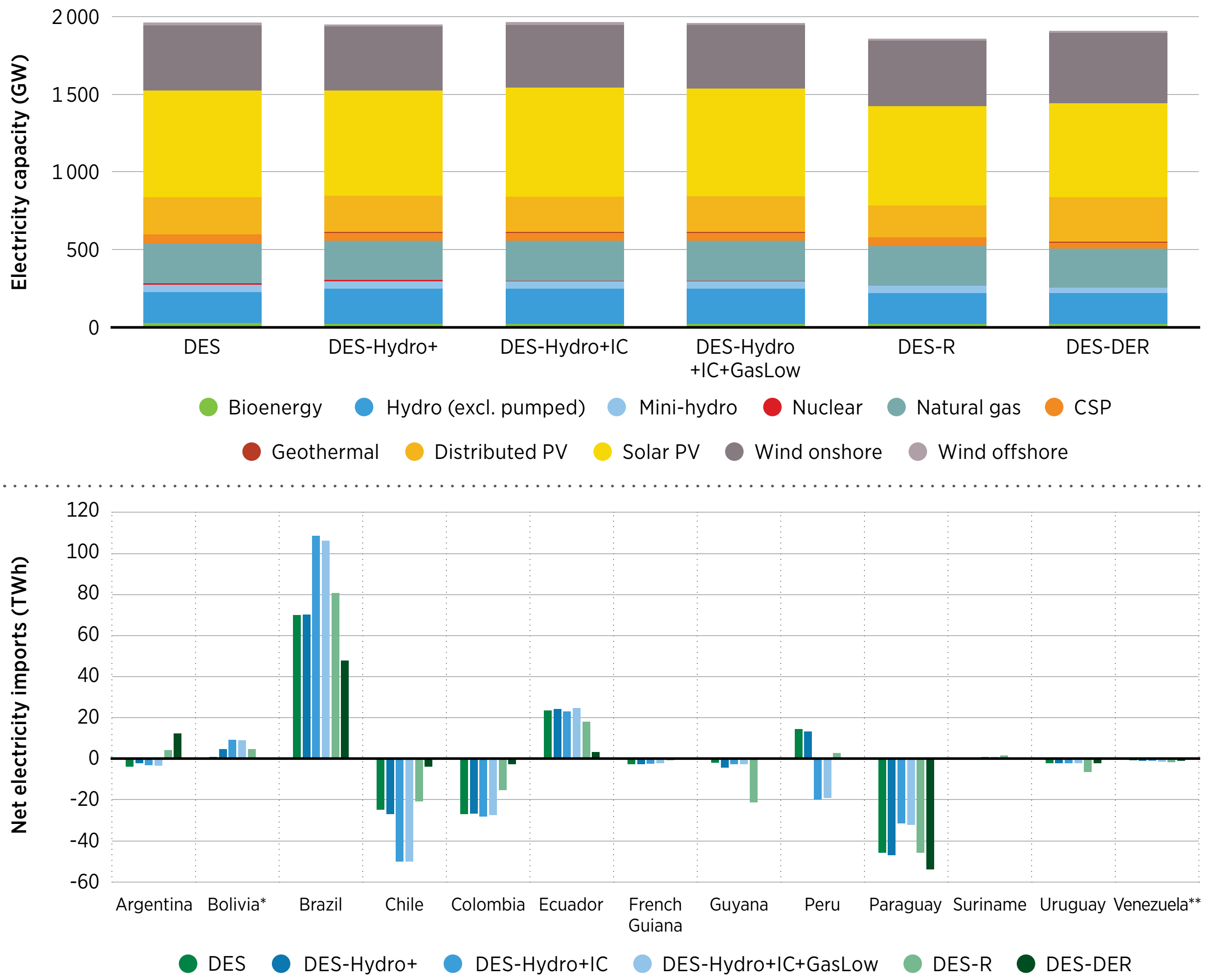
| SCENARIO | TOTAL INSTALLED CAPACITY | TOTAL INTERNATIONAL POWER TRADE | SYSTEM EVOLUTION BY 2050 | REGIONAL TRADE DYNAMICS BY 2050 | KEY INSIGHTS |
|---|---|---|---|---|---|
| DES | 1 955 GW | 231 TWh | 1.96 TW total capacity, with 86% renewables and 69% VRE. Solar is the largest source (927 GW), hydropower remains central (246 GW), and gas is still substantial (259 GW). | Brazil is the region's major importer, with 70 TWh of net imports. Peru (14 TWh) and Ecuador (24 TWh) are the other major importers. Chile (25 TWh), Colombia (27 TWh), Argentina (4 TWh) and Paraguay (46 TWh) export to meet this load. All other countries remain closely balanced with limited net flows. | The baseline DES combines a balanced renewable-heavy generation mix with moderate gas reliance. Brazil emerges as the structural importer, sustained by consistent flows from a small group of exporters, highlighting the region's asymmetrical trade dependencies. |
| DES-Hydro+ | 1 948 GW | 229 TWh | Hydropower expands to 292 GW, reinforcing clean firm capacity. Little change in overall mix; Natural gas capacity remains at 250 GW; renewables and VRE shares remain at 87% and 68% respectively. | Trade flows shift slightly. Import roles for Brazil (70 TWh), Ecuador (24 TWh) and Peru (13TWh), and export roles for Chile (27 TWh), Argentina (2 TWh), Colombia (27 TWh), and Paraguay (47 TWh) remain consistent with broadly similar amounts of power flows. | Additional hydropower capacity strengthens firm, low-carbon supply but leaves system costs, capacity mix, and cross-border dependencies largely unchanged. This points to a resilient baseline configuration where extra hydropower adds redundancy rather than altering core trade relationships. |

| SCENARIO | TOTAL INSTALLED CAPACITY | TOTAL INTERNATIONAL POWER TRADE | SYSTEM EVOLUTION BY 2050 | REGIONAL TRADE DYNAMICS BY 2050 | KEY INSIGHTS |
|---|---|---|---|---|---|
| DES-Hydro+ IC | 1 961 GW | 318 TWh | Regional interconnection enables better optimisation. Hydropower increases marginally to 277 GW, gas remains similar at about 251 GW and solar PV increases to 926 GW as regional balancing improves. Renewable and VRE shares are 87% and 69% of capacity, respectively. | Brazil's net imports jump to 109 TWh while Ecuador's remain at 23 TWh. Peru flips from importing to exporting 20 TWh, mostly solar. Argentina remains a modest net exporter (3 TWh). Chile (50 TWh), Colombia (28 TWh), and Paraguay (32 TWh) retain export roles. | Expanded interconnection reduces total capacity needs and redistributes renewables more effectively across the region. Trade roles shift, with some traditional importers turning into exporters, showing that grid integration can unlock generation potential and rebalance dependencies. |
| DES-Hydro+ IC+ GasLow | 1 959 GW | 314 TWh | Despite cheaper gas, capacity mix remains relatively unchanged at 252 GW. Renewables still dominate with the same renewable energy and VRE shares as DES-Hydro+IC. | Trade patterns unchanged vs. DES-Hydro+IC. Clean energy continues flowing into Brazil. Exporters hold their positions. | Cheaper gas has negligible structural impact in a deeply decarbonised, interconnected system. Trade patterns remain shaped by renewable and interconnection dynamics rather than fuel price signals, reinforcing gas's diminished strategic role by 2050. |
| DES- R | 1 855 GW | 235 TWh | Capacity reserve co-ordination reduces need for reserves. Efficiency improves without expanding capacity as significantly but delivering the same energy service. | Brazil's net imports fall to 81 TWh. Net exports from Chile and Colombia sharply reduce, as do Ecuadoran net imports. While Peru moves from being a net exporter to being a net importer of 3 TWh. Paraguay reverts to higher DES levels of exports while Guyana sharply increases exports to 21 TWh. Other countries remain stable in their power trade. | Regional co-ordination on capacity reserves delivers the largest capacity and cost reductions, limiting the need for redundant generation across borders. This reconfigures trade relationships by reducing energy imports for key demand centres and optimising reserve provision at a regional scale. |
| DES- DER | 1 906 GW | 91 TWh | Distributed energy rises with transmission expansion limited and focus on distributed renewables. | Brazil's, Ecuador's and Peru's imports drop sharply to 48 TWh, 3 TWh and 0 TWh, respectively. Argentina imports rise to 12 TWh. Chile, Colombia and Guyana see their exports reduced significantly to 4 TWh, 3 TWh and 0 TWh, respectively. Other countries retain their relatively balanced positions. | Greater reliance on distributed resources reduces interdependence between countries, resulting in a more self-sufficient but costlier system. The weakening of traditional export-import links demonstrates the trade-off between decentralisation and the efficiency gains of regional integration. This weakening also accentuates the need that strategic electricity-intensive projects be located near the renewable resources deployed |

### DES system-wide findings

Across all five "what-if" scenarios analysed for DES, total installed capacity remains similar, with renewables being between 1.86 TW and 1.96 TW, and renewable energy's share of total power generation capacity around 86-87%. However, these headline figures mask meaningful shifts that become apparent when considering how net imports of electricity vary internationally.

**Figure 5.7** Total installed power capacity mix (GW) (top) and net electricity imports (TWh) (bottom) under the DES and all "what-if" scenarios, 2050




**Notes:** * The Plurinational State of Bolivia; ** The Bolivarian Republic of Venezuela; Bioenergy = includes biomass solid and biomass solid carbon capture and storage; CSP= concentrated solar power; DES = Decarbonising Energy Scenario; GW= gigawatt; PV = photovoltaic; TWh = terawat hour.
DES-Hydro+ = expanded hydropower; DES-Hydro+IC = expanded hydropower and regional interconnection;
DES-Hydro+IC+GasLow = expanded hydropower, regional interconnection and sustained low gas prices;
DES-R = co-ordinate capacity reserves region-wide; DES-DER = expand distributed energy resources.

The most striking at a continental level in terms of installed capacity is the DES-R scenario, which demonstrates that capacity needs are 100 GW lower compared to the central DES, where capacity reserves can be met across international borders though interconnection lines, indicating that profound savings could be made.

To unpack these findings in more detail, Table 5.4 compares the results of the assessment and, when combined with Figure 5.7, shows several key insights and the conclusions derived from them.

This assessment shows that expanding regional interconnections (DES-Hydro+IC) unlocks substantial system efficiencies by enabling resource complementarity across borders and a more effective use of renewable wealth of South America. This allows for countries and regions with plentiful water or wind resources to play a larger role in supplying neighbours, reducing the need for duplicative capacity investments. While regional integration enables access to large hydropower resources, the results also show that large hydropower expansion only comes late in the horizon - only around 30 GW of the 225 GW technically available potential is developed within the model horizon. Although large hydropower could compete with the current levelised cost of renewables plus storage, these projects typically fall outside countries' own planning timelines (beyond 2035), where learning effects favour other low-emission generation and storage combinations.

Moreover, transmission expansion not only facilitates hydropower trade but also boosts solar deployment, particularly in Chile and Peru. The 9 GW DC transmission corridors initially conceived for hydropower exports are instead largely used to transfer solar generation once cross-border ties with Chile are reinforced. Only one of thirteen large hydropower projects is built, with the rest of the new transmission mainly supporting solar flows. Bolivia also emerges as a key regional hub, receiving over 20 TWh per year from Chile to re-export to Brazil, while Peru co-ordinates with Chile to export around 60 TWh to Brazil.

This effect is amplified when capacity reserves are also shared across borders (DES-R), which delivers the largest reduction in capacity requirements (which is around 100 GW less than the baseline DES) alongside the lowest total system cost across all scenarios. This suggests that regional reliability planning can be as important as energy trade in delivering cost-effective decarbonisation.

Additionally, the distributed energy-focused pathway (DES-DER) demonstrates that prioritising local autonomy without parallel transmission expansion increases total system capacity and costs. Most crucially, the DES-DER highlights that natural gas plays an even greater role, in system operation, when cross-border exchanges are constrained and despite strong constraints on $CO_2$. Without additional interconnection and international system integration, achieving a net-zero power system in South America becomes significantly more challenging. The results suggest that reduced cross-border exchanges, driven by local transmission constraints and the priority of distributed energy resources, limit system flexibility. This, in turn, increases reliance on gas and raises questions about whether the annual share of 98% renewables in the DES can be maintained. Even though it reduces reliance on imports—most strikingly through the elimination of hydropower exports from Guyana to Brazil, which reduces its hydropower capacity from nearly several gigawatts in all other DES cases to around 750 MW—the DES-DER also reveals a broader geographic shift in renewable deployment. Wind generation moves away from the high-capacity factor sites in Patagonia towards more central, lower-capacity factor wind farms. Hydropower developments for export in Peru and southern Argentina stall, while hydrogen production in Chile shifts southwards, relying increasingly on wind rather than the solar resources of the north. While such approaches can enhance local resilience, they require additional backup capacity, often from fossil fuels, and therefore may not maximise system-wide efficiency. On the other hand, for a system which reduces interdependence greatly compared to other scenarios, its only single digit percentage increases in terms of its impacts on overall costs for the power sector while considering that wind and solar resources closer to load centres are viable to export.

Importantly, the scenario with lower gas prices (DES-Hydro+IC+GasLow) confirms that in a renewables-dominated system, the marginal impact of fossil fuel price shifts on the long-term capacity mix is minimal. However, it still plays a key role in meeting capacity needs in the region during low-renewables periods, which is essential for system reliability. This underlines the resilience of a decarbonisation strategy centred on renewables, even under varying fuel market conditions.

A vast range of rich insights can be gained from this assessment. For policy makers, there are several key conclusions:

- Prioritise regional interconnection and co-ordinated capacity reserve markets to unlock large cost savings and reduce the need for excess capacity.
- Use distributed energy solutions strategically, complementing rather than replacing regional co-operation, to balance local resilience with overall efficiency.
- Maintain a long-term focus on renewables deployment, as fossil fuel price volatility has little impact on a deeply decarbonised power system.

Taken together, these results reinforce the proposition that integrated planning at both national and regional levels is essential to build a cost-effective, reliable and sustainable electricity system for South America's clean energy future.

## 5.3 POLICIES FOR THE POWER SECTOR TRANSFORMATION

The analysis of South America's electricity future under the PES, DES and complementary "what-if" scenarios paints a clear picture: the continent's abundant renewable resources offer the foundation for a nearly fully decarbonised, resilient and economically viable power system by mid-century – but only if ambition is matched with co-ordinated action.

Three themes stand out above all. First, renewable integration rather than scale is the challenge. The renewable capacity required to meet demand exists many times over in the form of hydro, wind and solar potential. The real challenge lies in connecting these resources to where and when they are needed through robust grids, regional interconnections and harmonised operational frameworks. Without this, countries risk building parallel, underutilised systems that miss out on the cost and reliability benefits of shared resources.

Second, system flexibility is key in delivering a renewable future. The DES and its variants show that battery storage, demand-side management and regional reserve sharing can dramatically reduce the need for redundant capacity. Scenarios such as DES-R demonstrate that co-ordinated capacity reserve sharing is as important as physical energy trade, delivering the largest cost savings and capacity reductions of all pathways examined. At the same time, maintaining parts of the existing thermal infrastructure appears to be a cost-effective strategy for ensuring system reliability and operational flexibility. While decommissioning older units may seem an attractive measure, it can often prove more expensive than retaining and retrofitting existing plants for secure operation, backup, and peak coverage. This is reflected in the DES, which identifies only about 9 GW of optimal thermal decommissioning (beyond the countries' planned phase-outs) compared to roughly 200 GW of new thermal capacity additions, conversions, and retrofits. The gas capacity that remains in the system under the DES indicates that future technologies enabling higher flexibility will need to be explored further, as highlighted in IRENA's Innovation Landscape series, which showcases innovative solutions for enhancing system integration and flexibility (IRENA, 2019a, 2023b). A clean, high-renewables grid will not function without an equally sophisticated flexibility strategy.

Third, policy decisions made today will have a strong influence on the cost and characteristics of the system over the long term. Distributed energy can improve energy access, enhance local resilience and autonomy, but without complementary transmission investment, it raises system costs and increases fossil backup needs. Governments must also prepare their respective power markets for any expansion of distributed generation, which can lead to operational challenges for distribution companies, including reverse power flows and grid stability concerns, prompting regulatory debates over limits and compensation mechanisms (as is the case in Brazil). Similarly, fossil fuel price changes (including cheaper gas) have negligible influence on the long-term generation mix in a deeply decarbonised system, reinforcing the view that renewables are the bedrock of South America's future power sector.

South America can secure a low-cost, low-carbon electricity future that meets a fourfold increase in demand while strengthening energy security. To achieve it, governments and regional bodies need to:

- Invest in transmission and cross-border interconnections as strategic infrastructure.
- Establish regional markets for firm capacity sharing, ancillary services and flexibility.
- Plan renewable and storage expansion with both local resilience and continental optimisation in mind.
- Streamline permitting, harmonise technical standards, and align planning assumptions across borders.

**Table 5.5** Summary of actions and measures needed for the power sector transformation

| PRIORITY AREA | MEASURE | ACTION NEEDED | EXPECTED IMPACT |
|---|---|---|---|
| **Reliability & Resilience** | Strengthen regional and national system reliability | Develop co-ordinated reliability standards, enhance grid protection schemes, and improve operational co-ordination between system operators. Include contingency planning based on recent blackout experiences and upcoming supply risks. | Improves security of supply, prevents regional blackouts, and strengthens resilience under extreme conditions. |
| **Planning & co-ordination** | Align national and regional energy plans | Create a permanent regional energy co-ordination body with joint forecasting and scenario modelling. | Improves investment certainty, optimises capacity mix. |
| **Permitting & governance** | Streamline approval processes | Define clear, transparent timelines and responsibilities for transmission, renewable and storage projects. | Reduces project delays, increases investor confidence. |
| **Technical standards** | Harmonise grid codes across countries | Standardise requirements for renewable integration, inverter behaviour, and frequency response. | Facilitates cross-border flows and market integration. |
| **Transmission & interconnection** | Expand and reinforce regional and national grids | Develop and fund regional interconnection projects with agreed cost-sharing frameworks. Reinforce and optimise existing networks through grid enhancing technologies and reconductoring. Ensure national grids are strengthened to handle cross-border flows. | Enables renewable resource sharing, reduces curtailment, lowers reserve margins, and avoids bottlenecks. |
| **Regional market integration** | Work towards an integrated regional market with joint grid planning and shared auction mechanisms | Co-ordinate capacity reserves, strengthen cross-border links, and enable flexibility sharing. | Reduces system costs, improves resilience, and boosts competitiveness. |
| **Renewable deployment** | Accelerate large-scale solar, wind, and hydropower build-out | Introduce streamlined permitting, stable auctions, and local manufacturing incentives. | Increases renewable penetration to >95%, supports green industrialisation. |
| **Hydropower** | Advance sustainable development and modernisation of existing hydropower | Strengthen regional co-operation on reservoir management, hydrological data exchange, sustainable potential assessment, and environmental and social standards. | Provides reliable capacity, seasonal storage, and system flexibility, enabling greater integration of wind and solar, and reducing reliance on fossil fuels. |
| **Distributed Energy Resources (DER)** | Enhance production, control systems, and co-ordination with distribution and grid operators | Improve centralised and co-ordinated distributed generation resource dispatch for load balancing. Integrate distribution network planning, flexibility, and adaptation to dynamic demand and generation patterns. | Reduces dependency on large transmission corridors, speeds up integration of renewables, and reduces the need for traditional firm generation at peak load. |
| **System flexibility** | Develop regional capacity reserve sharing and national flexibility supports | Harmonise grid codes; create cross-border platforms for reserve sharing and frequency control. National targets and policy mechanisms to enable deployment are needed. Future technologies that enable higher flexibility such as long-duration energy storage and clean fuel peaking plants could also meet this need. | Reduces total capacity needs by up to 100 GW, lowers system costs. |
| **Storage integration** | Scale battery and pumped hydro storage | Provide investment incentives to create conditions for developing business cases, integrate storage in capacity planning and grid codes. | Balances variability, reduces fossil backup, improves reliability. |
| **Digitalisation and new technologies** | Accelerate deployment of smart grids, advanced monitoring, and digital platforms for real-time system operation | Advance digitalisation through real-time data platforms, AI-based forecasting, digital twins and robust cybersecurity and interoperability standards; complement with new technologies such as high-voltage direct current links between 50/60 Hertz systems, large-scale storage and demand response solutions. | Enhances cross-border interconnection, improves reliability, strengthens cybersecurity and supports efficient integration of renewables across the region. |
| **Gas transition management** | Retain gas for strategic reserve only | Phase down gas generation hours while maintaining flexible capacity for extreme conditions. Regulatory mechanisms such as capacity payments may be needed to make it feasible | Ensures reliability without undermining decarbonisation trajectory |
| **Green industrialisation** | Leverage renewable build-out for industrial growth | Support clean hydrogen, low-carbon metals and battery industries tied to renewable supply including through R&D investments, targeted public-private partnerships and financial mechanisms such as investment platforms to de-risk projects. | Creates jobs, diversifies economies, strengthens export potential. |

06

# ENERGY TRANSITION PATHWAYS: **BIOENERGY**

## INSIGHTS AND RECOMMENDATIONS FOR THE ENERGY TRANSITION OF THE BIOENERGY SUPPLY

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ Bioenergy accounted for 19% of South America's total energy supply in 2023; under the DES it would rise to around 36% by 2050, requiring over 13 exajoules (EJ) of sustainable biomass. South America's favourable climate, land, water, and agricultural base make it well placed to scale up sustainable bioenergy production | ★ Align bioenergy development with land, water, and agriculture policies to ensure sustainability and resource efficiency; strengthen data collection; establish sustainability standards and certification. Use carbon pricing and tax incentives (*e.g.* VAT relief, accelerated depreciation) to enhance bioenergy competitiveness. |
| ★ Most new bioenergy demand will come from heating, mobility, and export markets sustainable aviation fuels (SAFs) and bio-bunkers. Brazil is already a net bioethanol exporter, while Argentina exports biodiesel. | ★ Establish national blending mandates for transport fuels, SAF and maritime bunkers. Create predictable demand via public procurement (fleets, utilities, ports, airports). Strengthen regional co-operation and certification schemes to harmonise standards and support trade. |
| ★ Under the DES, transport bioenergy use is estimated to grow over 65% by 2030 (1.4 EJ) and would reach approximately 2.3 EJ by 2050. Exports and bunkers would add 0.5 EJ by 2050. | ★ Introduce SAF blending targets and support SAF offtake agreements. Mandate biofuel use in public fleets and utilities. Establish regional market mechanisms to scale up deployment and ensure supply stability. |
| ★ Industrial bioenergy demand would more than double from 2.1 EJ in 2023 to nearly 4.9 EJ by 2050 under the DES, substituting fossil fuels in cement, steel, and other high-heat sectors. | ★ Adopt blending mandates for biodiesel, ethanol and biomethane. Expand use of successful policies (*e.g.* Brazil's RenovaBio) to guide regional co-operation and investment. Promote co-firing in cement, pulp and paper, and sugar/ethanol plants. |
| ★ Under the DES, sustainable bioenergy share in the final energy consumption of buildings would rise from 1% in 2023 to almost 3.5% in 2050, with biomethane in gas grids, ethanol for cooking, and solid biomass for heating. Moreover, traditional biomass share in the sector's TFEC would decrease from 17% today to less than 1% in 2050. | ★ Develop industry-led certification for biomass. Establish bioenergy hubs near ports and industrial clusters. Provide grants for digesters at farms, agro-industries, and landfills. |
| ★ Meeting projected demand under the PES would require around USD 70 billion in bioenergy infrastructure between 2025 and 2050, while the DES would need more than double the effort, around USD 146 billion, including biofuel and charcoal production. | ★ Establish biomethane blending mandates in gas pipelines and guarantee offtake agreements through tariffs or green certificates to make projects bankable. |

## 6.1 OVERVIEW OF BIOENERGY CARRIERS IN THE REGION

South America has been positioning itself as one of the world's leading bioenergy producers (IICA, 2024a). According to the Inter-American Institute for Cooperation on Agriculture (IICA), the production of liquid biofuels in Latin America has shown a steady increase over recent years. Their 2023 report highlighted that regional bioethanol production reached 37 million $m^3$ that year, with Argentina and Brazil contributing nearly 96% of the total. In addition, of the 9.4 million $m^3$ of biodiesel produced in the region in 2023, Argentina, Brazil and Colombia accounted for over 97% of the total output (IICA, 2024b).

Bioenergy, including both traditional and sustainable sources, accounted for 22% of the primary energy supply of the region in 2023 (5.3 EJ in total). In the power sector, bioenergy's share in same year accounted only to 5%, while in final consumption the direct uses of bioenergy covered 20%, including traditional biomass. In terms of the end-use sectors and the share of direct uses of bioenergy into their energy mixes, industry depicted the highest share in 2023 (28% of the sectorial TFEC), primarily in the form of bagasse, black liquor and solid biomass. Biomass has long been used in the pulp and paper industry to supply industrial heat and support cogeneration. It can also serve as a feedstock and source of process heat for the chemical and petrochemical sectors, and to provide high-temperature heat for energy-intensive industries. In the buildings sector bioenergy made up nearly 18% of the sectorial TFEC in 2023, largely in the form of traditional biomass for cooking. Lastly, bioenergy in the transport sector TFEC accounted for almost 13% of the total, mainly through the use of bioethanol and biodiesel blended into their fossil counterparts.

In Latin America, biofuels account for twice the global average in road transport (IEA, 2023c). Thanks to abundant renewable energy resources, Argentina, Brazil, Chile and Colombia could become major producers of low-cost, low-emission hydrogen and related fuels. Biofuels are responsible for 10% of the energy used for power generation and transport (compared to less than 5% globally) (IEA, 2023c). Over time, biofuels have the potential to increase productivity and utilise advanced feedstocks, contributing to decarbonisation in hard-to-abate sectors. Furthermore, advanced biofuels, particularly SAFs, offer promising export opportunities and could position the region as a key supplier in global low-carbon fuel markets.

With supportive policies, biogas and biomethane could play an increased role in power generation and transport due to the region's significant potential for their production. Currently, biogas production mainly uses maize, sugar cane and soybean crops, with smaller contributions from animal manure and organic municipal waste. Argentina and Brazil have already approved national waste strategies designed to increase the availability of feedstock for biogas production.

Bioenergy is also a key element of biorefineries, which have emerged as pivotal components in South America's transition toward sustainable energy and circular bioeconomy models. Bioenergy and biorefineries are intrinsically linked, as biorefineries serve as the production facilities that convert biomass - such as crops, agricultural residues, algae and waste oils - into biofuels through processes like fermentation, pyrolysis and chemical refining. These facilities operate similarly to petroleum refineries but prioritise renewable resources, transforming organic matter into liquid fuels (*e.g.* ethanol, biodiesel, SAF) and co-producing materials like bioplastics, fertilisers and biogas. Various initiatives and new developments have been observed in South America to establish biorefineries that align with their unique resources and economic contexts (see Box 3).

To ensure sustainable bioenergy deployment, identifying the type, source and regional availability of sustainable biomass resources is a key first step. IRENA's report on agricultural residue-based bioenergy has assessed South America's potential for biomass resources from agricultural residues, highlighting the availability of materials such as soybeans, broiler hens and sugarcane (IRENA, 2023c). It is estimated that about 7.3 EJ of agricultural residues is generated per year. Despite its significant potential, much of South America's biomass waste remains underutilised, often burned or landfilled.

According to the 2023 *Analysis of current biofuels outlook* by Brazil's EPE, the use of "land-sparing" techniques could enable the annual production of 23–85 billion litres of bioethanol and 4–10 billion litres of biodiesel. These estimates are based on the potential from energy crop expansion (via degraded pastures and second harvests), agricultural residues, and productivity gains (EPE, 2024a).

However, just like any other land-based activities, if not managed sustainably, bioenergy deployment may pose potential sustainability risks. These risks include land use changes, air pollution, impacts on water and soil quality, biodiversity loss, competition with food production, and potential effects on indigenous communities and smallholders. A key debate regarding expanding bioenergy, especially in the cases of weak land use governance, is the risk of converting high-carbon forests into low-carbon monoculture crops or timber plantations. Cautious planning and robust regulatory oversight are essential for bioenergy production, particularly in biodiversity-rich regions such as South America. Implementing strong governance frameworks, clear sustainability standards and transparent land-use policies can help mitigate these risks effectively.

Global bioenergy trade has grown in recent decades due to the uneven distribution of biomass resources and demand. Argentina's biodiesel was mainly exported to Europe, while Brazil's bioethanol was exported mainly to South Korea, India and Saudi Arabia (Reuters, 2024b). In contrast, Colombia and Peru imported bioethanol to meet their internal demands.

At the international level, various programmes and associations are exploring the role of bioenergy carriers in the energy transition. The Global Bioenergy Partnership is hosted by the Food and Agriculture Organization), with regional members including Argentina, Brazil, Colombia, and Paraguay; Chile, Peru and Uruguay are observers. In addition to the Global Bioenergy Partnership, the Global Biofuels Alliance, launched by India during its G20 presidency, includes Argentina, Brazil and Paraguay as members.

Sectorial organisations such as the ICAO and IMO have dedicated projects, such as the Future Fuels and Technology Project, aiming to support the reduction of GHG emissions from international shipping. Moreover, in September 2025, IRENA and ICAO launched the *Finvest@ETAF* portal to support SAF and clean aviation energy projects globally (IRENA, 2025d).

Numerous platforms in the region are incorporating bioenergy into their discussions. One of these is the Clean Energy Ministerial's Biofuture Platform Initiative, which includes Argentina, Brazil, Paraguay and Uruguay, among other 19 countries. The initiative aims "to lead global actions to accelerate development, scale-up, and deployment of sustainable bio-based alternatives to fossil-based fuels, chemicals, and materials" (CEM, 2024). Another initiative is the Latin America and the Caribbean Platform for Resilient and Low Emission Development, a regional platform of the Global Climate Action Partnership, which provides a space for countries to engage in dialogue on low-emission and resilient development strategies.

Many South American countries are members of IICA, an agency specialising in agricultural matters that supports the development of policies, standards and regulations at both national and international levels, tailored to the needs of bioeconomy sectors. In 2023, during the Pan American Liquid Biofuels Summit, the Pan American Coalition for Liquid Biofuels was established, with IICA acting as its technical secretariat. The coalition brings together leading business and industry associations across the Americas involved in the production and processing of sugar, alcohol, corn, sorghum, soybeans, vegetable oils, grains and other agricultural products.

This chapter outlines the key results, insights and takeaways from the bioenergy analysis conducted for South America, addressing key questions such as:

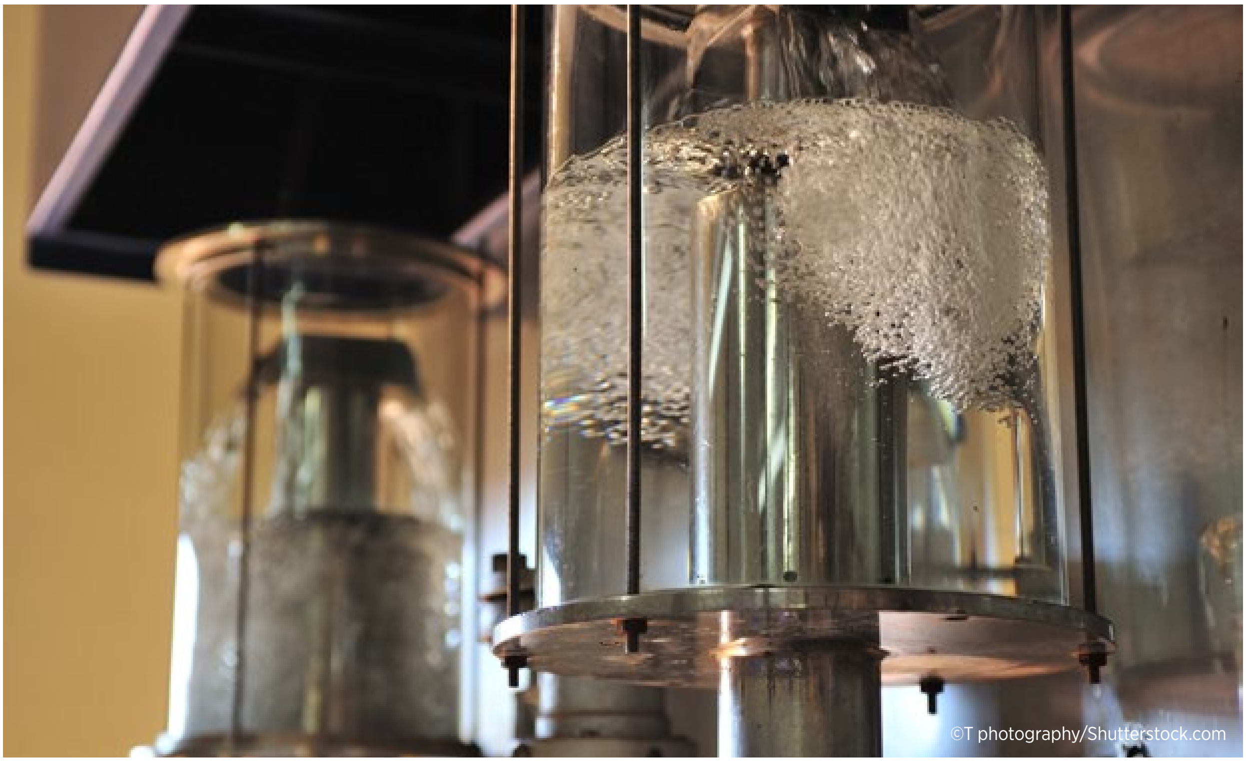
- What is the current state of bioenergy consumption, and how might it change under various scenarios?
- What are the potential benefits and risks associated with expanding its use?
- What challenges might arise in its implementation, and how far can we realistically go in achieving sustainable bioenergy development?

**Box 6.1** Bio-refineries in South America

Brazil stands at the forefront of biorefinery development, primarily through its extensive sugarcane industry. The country's sugarcane biorefineries produce ethanol, electricity and other by-products by utilising bagasse – a fibrous residue from sugarcane – as a key feedstock. Various innovative projects are also expanding Brazil's biorefinery capabilities. For example, the corn-based biorefinery planned by ICM and Energy Impact (Impacto Energia) can diversify Brazil's biofuel feedstock base, producing ethanol, corn oil and animal feed (Bioenergy International, 2022).

Argentina's prominent role in agriculture makes the development of biorefineries a national priority. For example, to bolster this sector, the Undersecretariat of Food, Bioeconomy, and Regional Development launched the Argentine National Biodevelopment Programme (Programa Nacional Biodesarrollo Argentino [Biodesarrollar]) to drive the innovation, development and adoption of bioproducts – from biotechnology and bio-inputs to biomaterials and bioenergy – to enhance growth and competitiveness in Argentina's agribusiness and related industries (USDA, 2023). Another example is the transformation of the San Lorenzo refinery, previously operated by state-owned YPF, into a sustainable biorefinery. The Santa Fe Legislature approved legislation facilitating this conversion, aiming to repurpose the defunct fossil fuel refinery into a facility producing SAF and other bio-based products (Advanced Biofuels USA, 2024).

Colombia's biorefinery landscape is characterised by its diverse bio-based resources. The country has introduced its National Bioeconomy Strategy (Colombia BIO), an ambitious strategic framework that seeks to transform the nation's abundant biodiversity and agricultural resources into a sustainable driver of economic growth and job creation. Efforts are underway to utilise different types of bio-based resources for biochemicals and bioenergy production, aiming to boost rural economies and reduce their environmental impact (Minciencias, 2025).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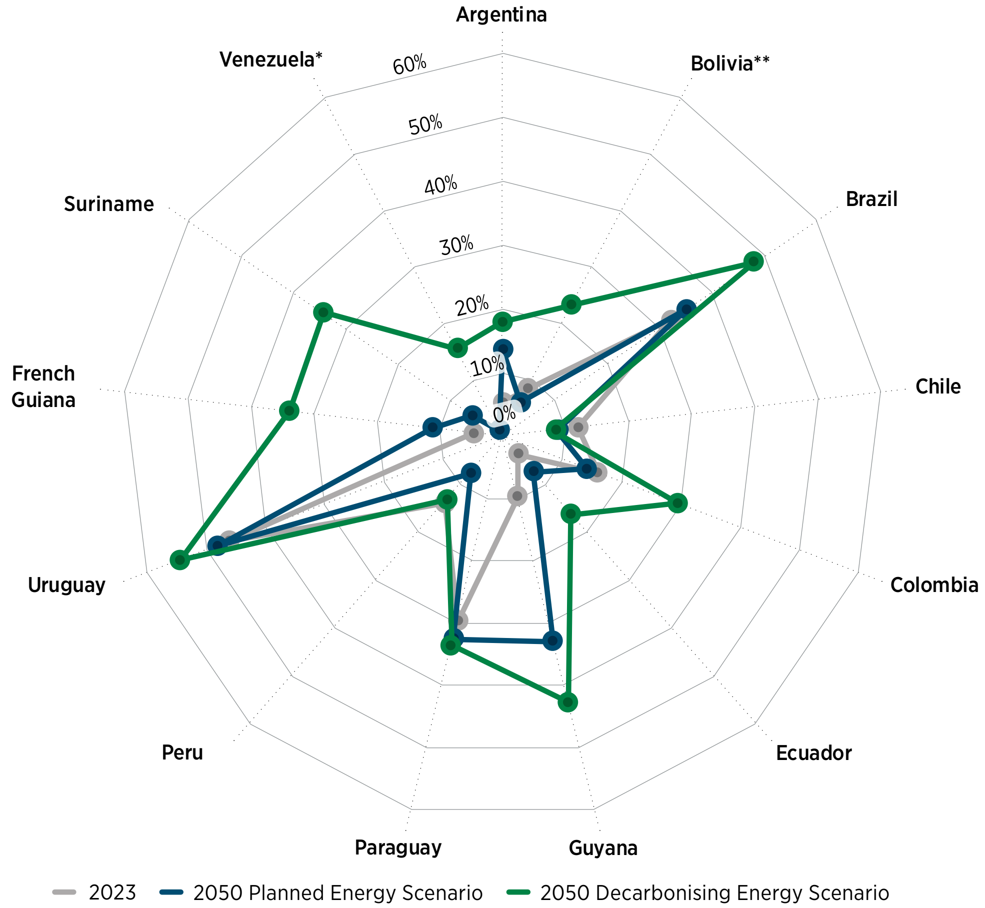
## 6.2 ROADMAPS FOR BIOENERGY

The expansion of sustainable bioenergy production and uses are critical to advancing the energy transition. Sustainable bioenergy's potential to replace fossil fuels is particularly compelling in South America, considering that the region offers favourable climate conditions, along with abundant water and land resources to expand biomass production (IRENA, 2022c). In addition, the region's centuries-old agricultural tradition, combined with the steady expansion of the biofuels market provides a strong foundation for sustainable energy development.

In the PES, the share of bioenergy in the primary energy supply would reach 25% by 2050, while under the DES, it would rise to 36%, considering both traditional and sustainable bioenergy. This transition includes phasing out inefficient traditional biomass currently used for cooking and heating. Figure 6.1 presents the share of bioenergy in the primary energy supply across all countries. In 2023, only three countries are over 30%, while by 2050 in the DES more countries would achieve same level. Brazil and Uruguay stand out, as they are projected to achieve the highest shares in the region. In Brazil, this is primarily driven by an increase in biofuel production, while in Uruguay, it results from a combination of black liquor generated in the pulp and paper industry and solid biomass.

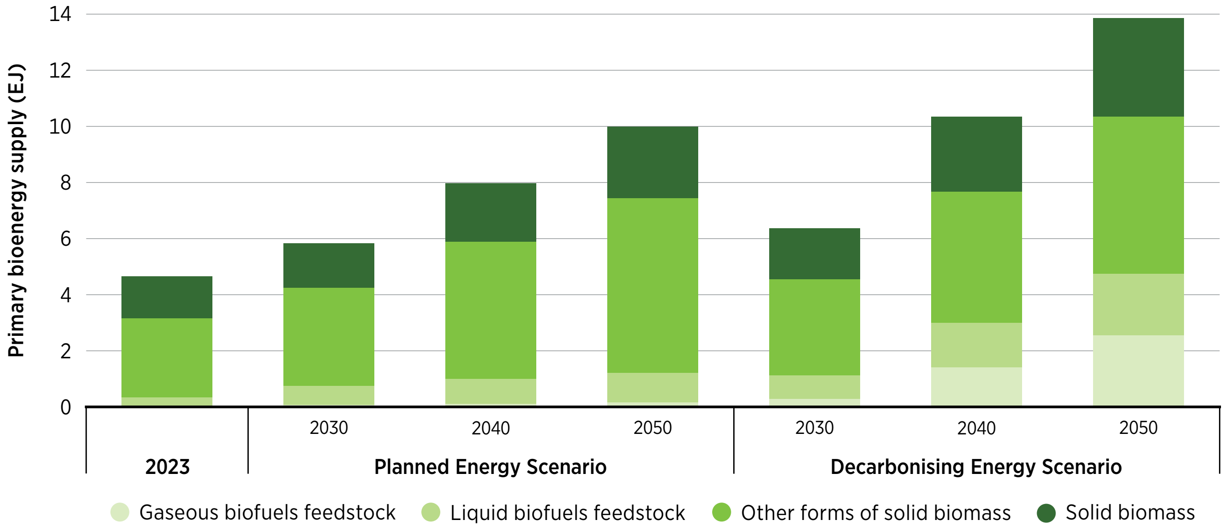
**Figure 6.1** Bioenergy share in primary energy supply in South America in 2023, and under the PES and DES by 2050, by country




**Note:** Primary supply includes both traditional and sustainable bioenergy; * The Bolivarian Republic of Venezuela; ** The Plurinational State of Bolivia.

Figure 6.2 shows the regional primary bioenergy supply by energy carrier. Feedstock for gaseous biofuels would grow up to 2.6 EJ in the DES by 2050, with a production of 30 billion $m^3$ (compared to the 2 billion $m^3$ under the PES), driven mainly by the integration of biomethane into the natural gas grid to reduce carbon emissions.

**Figure 6.2** Primary bioenergy supply in South America under the PES and DES, by energy type, 2023-2050




**Note:** The category of gaseous biofuels refers to their uses in final consumption. Country energy balances in historic years reflect use of biogas for electricity generation, which is embedded in the "solid biomass" category. Modelling of power plants based in bioenergy carriers are aggregated into one single category, namely "Bioenergy", presented in Chapter 5.

Moreover, the feedstock used for liquid biofuel production is expected to triple by 2050 under the PES and increase by six times under the DES, compared to base year. By 2050, under the DES, the region is projected to produce over 82 billion litres of bioethanol (almost triple the 2023 level) and around 14 billion litres of biodiesel (nearly 50% higher compared to base year).

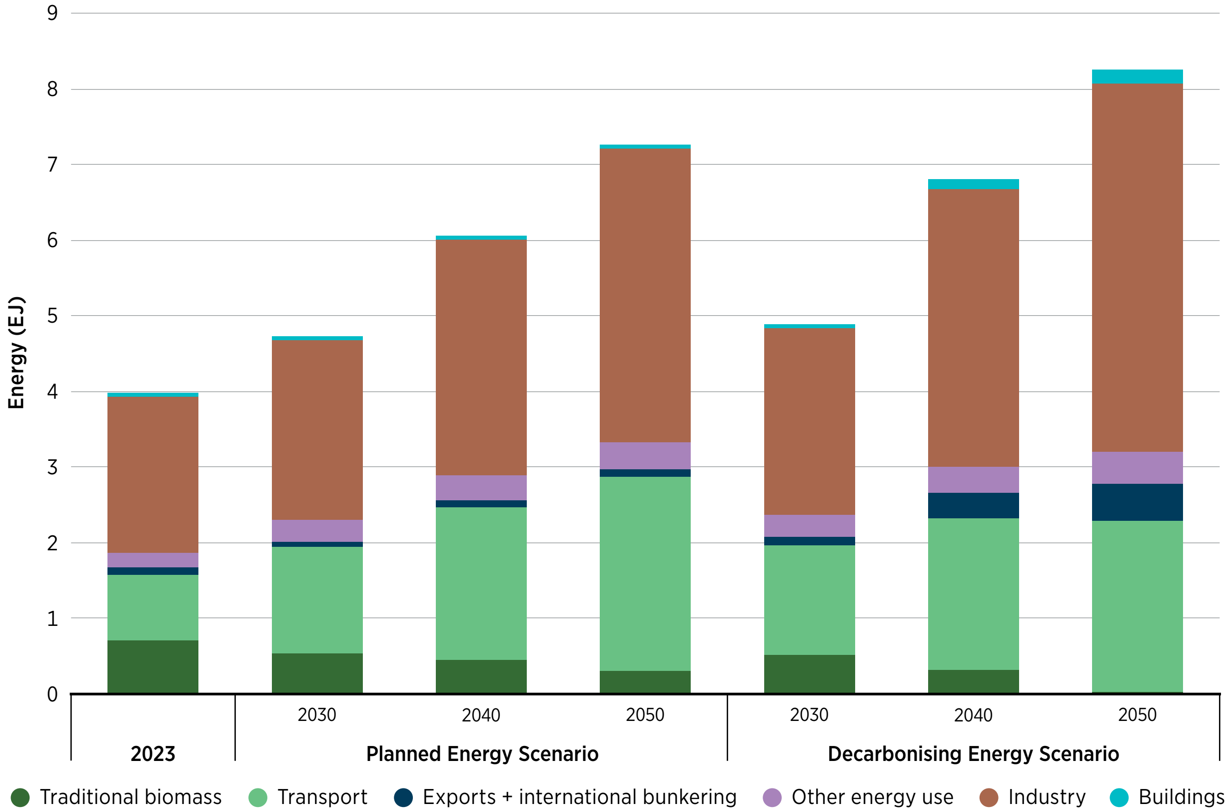
In terms of uses of bioenergy, Figure 6.3 illustrates the different sectors/purposes by scenario. In the case of traditional biomass, which is used exclusively in the buildings sector for cooking and space and water heating, both scenarios depict a decrease by 2050: nearly 60% under the PES compared to the base year, and over 95% under the DES (from 0.7 EJ in 2023 to less than 30 PJ in 2050). Meanwhile, sustainable bioenergy uses in buildings would reach 0.2 EJ in the DES by 2050.

In the transport sector, sustainable bioenergy use would be slightly higher under the PES, reaching around 2.6 EJ by 2050, compared to 2.3 EJ in the DES, as there is a greater fleet electrification in DES (aiming higher efficiency gains), reducing the number of internal combustion engine vehicles in which biofuels blending occur. Nevertheless, in terms of its share in transport final energy consumption, sustainable bioenergy would account for 35% in the DES by 2050 while 21% in PES, up from 13% in 2023.

Energy-intensive and high-temperature industry sectors—such as iron and steel, cement and lime, aluminium, and chemicals—are key areas of focus, where bioenergy has the potential to replace coke and coal. In the PES, sustainable bioenergy demand in industry would reach nearly 4 EJ, while in the DES, it would rise to 5 EJ. Its share in industry final consumption would increase from 28% in 2023 to 32% in the PES and 46% in the DES.

The aggregation of these sectors alongside other energy uses would imply an increase of the share of sustainable bioenergy in the total final energy consumption, from 16% in 2023 to 21% in PES and over 33% in DES by 2050.

**Figure 6.3** Bioenergy uses in South America under the PES and DES, by sectors, 2023-2050




The use of biomass coupled with CCS (known as BECCS) in the power sector, the production of biofuels and the use of CCS for some industrial sectors would be critical in decarbonising the region. A consultancy study done by COPPE for IRENA to develop scenarios for energy supply and demand of Brazil[43] determined that BECCS was the optimization model's selected option for their most ambitious scenario, over CCS from fossil fuels or industrial processes.

In the DES, CCS is applied to power generation, blue hydrogen production, and the cement and iron and steel industries, with deployment beginning in 2040, based on the current technology readiness levels. The total potential for $CO_2$ capture from processes that use biomass, to which CCS could in principle be applied, is estimated at around 60 $MtCO_2$ in 2050.

As mentioned earlier, limited access to affordable financing remains a key barrier to the development of bioenergy projects in the region. To help address this challenge, institutions such as the Inter-American Development Bank (IDB) offer financial support to national governments. One example is the project 'The Valuation of Pruning Waste as a Source of Renewable Energy' in Paraguay, which aims to develop a new renewable fuel by converting urban pruning waste—replacing unsustainable solid biomass currently used in industrial processes.

[43] *Consultancy services to support the work on South America Renewable Energy Roadmap (REmap) – Development of scenarios for energy supply and demand in Brazil, prepared by CenergiaLab/PPE/COPPE/UFRJ, 2022*

**Table 6.1** Bioenergy supply and consumption KPIs for achieving the PES and DES, 2023-2050

| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **BIOENERGY SUPPLY** | | | | | | | |
| Sustainable bioenergy primary supply (EJ) | 4.6 | 5.8 | 7.9 | 10 | 6.3 | 10 | 13 |
| Sustainable bioenergy share in TPES (%) | 19% | 22% | 24% | 25% | 24% | 31% | 36% |
| Production of bioethanol (billion L) | 30.5 | 43 | 65 | 85 | 43 | 66 | 82 |
| Production of biodiesel (billion L) | 9.5 | 18 | 22 | 26 | 20 | 21 | 14 |
| Production of biogas and biomethane (billion $m^3$) | 0 | 0.78 | 1.3 | 2 | 3 | 16 | 30 |
| **KPI. 01 RENEWABLES (POWER)** | | | | | | | |
| Bioenergy share in power generation (%) | 5% | 3% | 3% | 2% | 4% | 3% | 2% |
| **KPI. 02 RENEWABLES (DIRECT USES)** | | | | | | | |
| Sustainable bioenergy share in TFEC (%) | 16% | 19% | 20% | 21% | 20% | 27% | 33% |
| Sustainable bioenergy share in buildings TFEC (%) | 1% | 1% | 1% | 1% | 1% | 3% | 3% |
| Sustainable bioenergy share in industry TFEC (%) | 28% | 31% | 32% | 32% | 32% | 39% | 46% |
| Sustainable bioenergy share in transport TFEC (%) | 13% | 17% | 20% | 21% | 18% | 26% | 35% |
| **KPI. 06 CCS, BECCS AND OTHERS** | | | | | | | |
| BECCS carbon removal ($MtCO_2$/yr) | - | 0 | 0 | 0 | 0 | 0 | 58 |
| **TOTAL SYSTEM COSTS** | | | | | | | |
| Cumulative investment (2024 USD billion) | - | 20 | 25 | 24 | 28 | 56 | 63 |

**Note:** KPI's refer only to sustainable bioenergy, i.e., traditional biomass is not included. The cumulative values for sectorial system costs by column refer to the periods 2025-2030, 2031-2040 and 2041-2050. Values estimated considers the investment in infrastructure for biofuel plants and charcoal plants.

The PES anticipates almost USD 70 billion in cumulative bioenergy supply investments between 2025 and 2050, while the DES demands around USD 146 billion (more than double compared to the PES), reflecting the urgency of early action. These funds will largely support infrastructure modernization and growing energy demand.

In contrast, oil and gas transmission and distribution pipelines and oil refineries would face declining fossil fuel production over time, according to the DES: around 30% less by 2040, and approximately 70% by 2050, compared to current levels in primary supply. Retrofitting assets towards renewable fuels utilization could be economical, complemented with a coordinated process of renewable fuels supply to assure security and affordability.

The following subsections outline the primary bioenergy carriers used in South America.

### 6.2.1 Bioethanol and biodiesel

Biofuels are renewable fuels derived from biomass that can be blended with their fossil counterparts to reduce emissions in combustion engine vehicles. Bioethanol also serves non-energy purposes, primarily in the production of beverages, cosmetics, pharmaceuticals, petrochemicals, and oxygenated compounds such as acetic acid, ethyl acetate, and butanol.

**Bioethanol** can be produced from various feedstocks, depending on local availability. In South America, the primary sources are corn and sugarcane. Sugarcane can produce both first or second generation biofuels. First-generation sugarcane processing extracts juice from the stalk to produce sugar and bioethanol. In contrast, second-generation processing utilises by-products such as bagasse and trash to produce cellulosic ethanol, enhancing sustainability and reducing land use.

As mentioned above, the region produced around 40 million $m^3$ in 2023, with Argentina and Brazil accounting for over 90% of the total. According to IICA, Brazil alone produced just over 35 million $m^3$ and consumed slightly under 30 million $m^3$ domestically, while Argentina produced nearly 1.2 million $m^3$ and consumed approximately around 1.1 million $m^3$ in 2023 (IICA, 2024b). This indicates that the main ethanol producers in the region in 2023 were consuming between 85% and 90% of their output domestically.

In 2023, Brazil exported 2.5 million $m^3$, while Paraguay exported nearly 116 000 $m^3$ and Peru 158 000 $m^3$ (IICA, 2024b). Brazil is currently South America's leading ethanol exporter, with exports projected to reach 2.8 million $m^3$ by 2034, 12% over the 2023 value (EPE, 2024b). This growth is largely driven by sugarcane ethanol's contribution to United States Renewable Fuel Standard targets. Key importers are expected to remain the United States, South Korea, Japan, and the European Union. Paraguay is also active in bioethanol exports; however, the volume remains modest compared to Brazil.

**Biodiesel** can be produced through two main pathways: fatty acid methyl esters (FAME), generated via the transesterification of vegetable oils, and hydrotreated vegetable oil (HVO), also known as renewable diesel, produced through hydrotreating. Unlike FAME, HVO is fully compatible with existing diesel engines and provides higher fuel quality and better environmental performance. However, its higher production cost makes it less competitive compared to fossil diesel and even FAME-based biodiesel. Soybean oil is currently the primary vegetable oil used, but palm oil is expected to play a significantly larger role in the future (EPE, 2018).

As noted earlier, the region produced over 9 million $m^3$ of biodiesel in 2023, with Argentina, Brazil and Colombia accounting for over 95% of total output. Brazil alone produced 7.5 million $m^3$—nearly 80% of the regional total—and consumed just over 7.1 million $m^3$, representing 95% of its production (IICA, 2024b).

Argentina is among the top global exporters of soy-based biodiesel. In 2023, the country exported 0.3 million $m^3$ of biodiesel, representing a decline of 77% from 2022 and 75.2% from 2013, which can be explained by the economic situation of prices in its main market (the European Union) and the drought. In 2023, Paraguay entered the international biodiesel market for the first time, exporting 0.001 million $m^3$ primarily to Belgium and the Netherlands. With ongoing negotiations with the United States, exports are expected to rise in the coming years (IICA, 2024b).

### 6.2.2 Biogas and biomethane

Biogas is produced through the anaerobic digestion or gasification of organic wastes and mainly consists of 50% to 70% methane and 25% to 45% $CO_2$ and can be used to produce heat and electricity or upgraded to biomethane. Biomethane is purified biogas upgraded to achieve a composition similar to natural gas, with a methane concentration of around 98%. Due to it having the same chemical composition as natural gas, biomethane can be seamlessly blended into the natural gas grid without requiring structural modifications and can fully substitute it where needed.

According to the World Biogas Association, Brazil (which is one of the global top 10 priority countries for biogas) has an estimated biogas potential equivalent to 171 TWh (around 600 PJ) (World Biogas Association, 2021). In 2023, Brazil produced more than 19 PJ of biogas, around 917 million normal $m^3$, significantly below its estimated theoretical potential of 31.2 billion normal $m^3$ per year (EPE, 2024a) (Marcucci *et al.*, 2025).

In most countries of the region where biogas is produced, it is primarily used for power generation. However, some countries are conducting studies to explore the potential for upgrading biogas to biomethane and injecting it into the natural gas grid.

In relation to biomethane blending into the natural gas grid, the optimisation model used in the consultancy study by COPPE projected a 70% biomethane share in natural gas, reaching a production of nearly 900 PJ by 2050 in its most ambitious scenario.

Building on this insight, the DES envisions up to 30% biomethane blending into the natural gas grid by 2050 in selected countries. As several of these countries already produce biogas for electricity generation, existing expertise could be leveraged to support biomethane production for thermal applications, resulting in a projected demand of 960 PJ by 2050.

### 6.2.3 Aviation and maritime biofuels

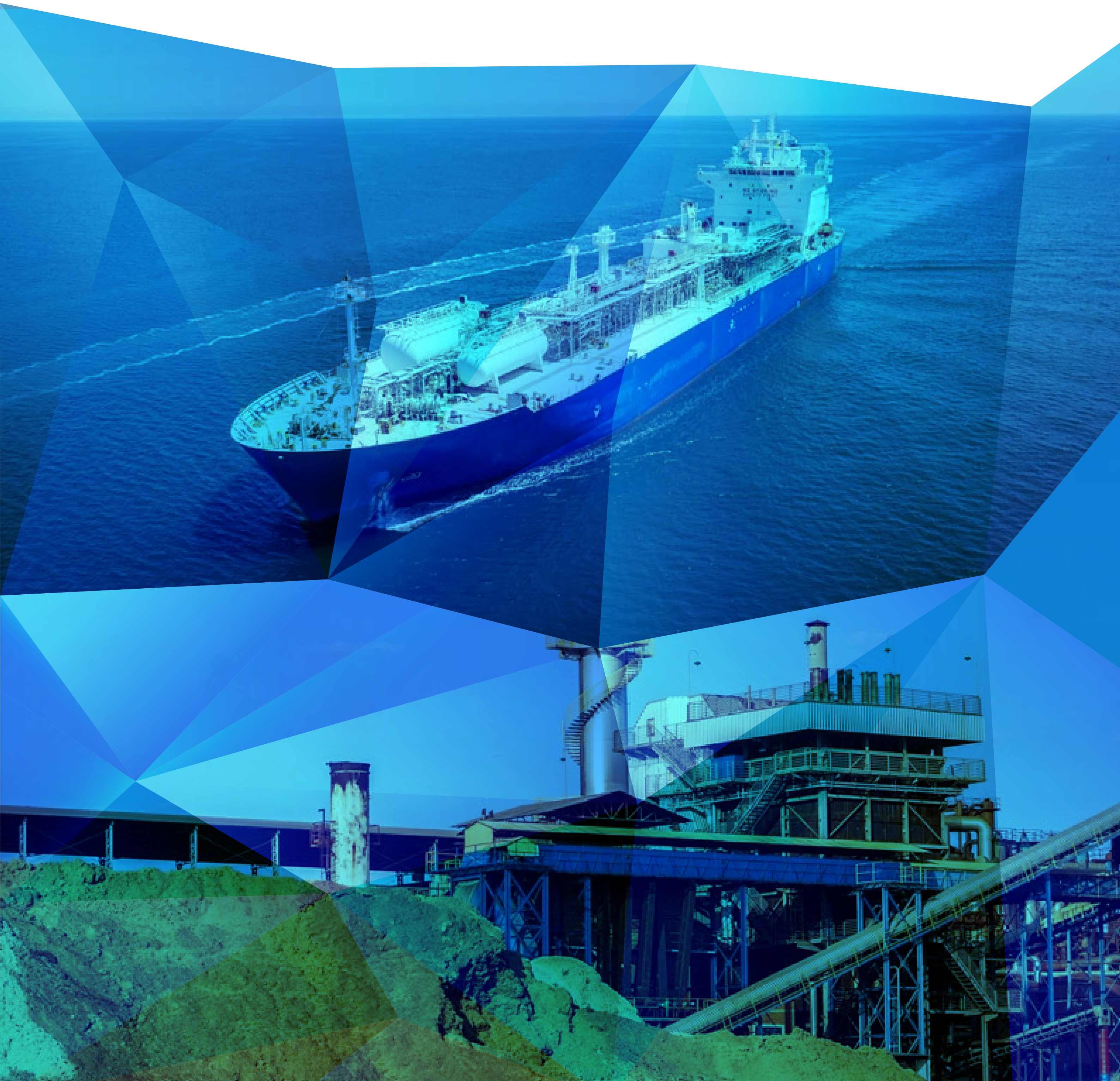
The aviation sector, represented by the International Air Transport Association (IATA), has committed to achieving net-zero carbon emissions by 2050 in alignment with the Paris Agreement (IATA, 2024). The IATA highlights the importance of SAFs making up at least 5% of total aviation fuel by 2030, as a key step toward decarbonising the sector (IATA, 2023). Notably, the ICAO adopted a global aspirational goal of net-zero carbon emissions by 2050 for international aviation, which will rely heavily on new technologies, operational improvements, and a major scale-up of SAF production and use. Achieving the net-zero 2050 goal will require unprecedented effort; for instance, ICAO estimates that about USD 3.2 trillion in investments will be needed globally for SAF production alone by mid-century (ICAO, 2024).

For South America, biojet fuel is anticipated to play a growing role in decarbonising aviation in the coming years to meet IATA's net-zero target. Under the DES, blending of aviation fuel with biojet begins in 2030 and progressively increases, reaching an 80% share by 2050 (IATA, 2025b). By end of the study period, biojet fuel needs would total approximately 740 PJ for domestic and international aviation.

South America's extensive land area enables the use of degraded land and existing farmland to meet ICAO sustainability criteria. A recent technical recommendation on SAF, introduced at the 13th triennial meeting of ICAO's Committee on Aviation Environmental Protection, highlighted multiple cropping, which is common in tropical regions, as a viable SAF feedstock practice (MRE, 2025). Updated methodologies now better reflect the land-use dynamics of tropical and subtropical areas.

In 2023, the IMO adopted the "2023 IMO Strategy on the Reduction of GHG Emissions from Ships," which sets a goal of reaching net-zero GHG emissions from international shipping by 2050 (IMO, 2023). As part of this strategy, at least 5–10% of the fossil fuels currently in use should be substituted with sustainable alternatives, such as biofuels (like HVO), hydrogen, ammonia, and methanol—by 2030.

While HVO is already being used in marine diesel engines, either pure or blended with fossil marine diesel, it is only used for short trips and in pilot projects for larger vessels.



## 6.3 POLICIES FOR THE EXPANSION OF BIOENERGY USES

Bioenergy plays a significant and growing role in South America's energy transition. However, suitable biophysical conditions for biomass production and attractive economic development are not sufficient for successful sustainable bioenergy production in the region. A stable legal and regulatory framework is crucial for bioenergy development, bridging natural resources and sustainable exploitation. Clear policies encourage private investment and minimise financial risks by ensuring commercial viability and legal certainty for various biofuels (IRENA, 2024c).

Argentina, Brazil and Colombia are currently major producers of biofuels and bioelectricity, serving their domestic markets and exporting surpluses. Table 6.2 summarises South American bioenergy production by country and feedstock.

**Table 6.2** Bioenergy production in South America, 2025

| COUNTRY | ETHANOL | BIODIESEL | BIOGAS / BIOMETHANE | SOLID BIOMASS (ELECTRICITY) | BIOJET / SAF |
|---|---|---|---|---|---|
| Argentina | Sugarcane and corn | Soybean oil | Organic waste from various sources, including agricultural and municipal waste[a] | Agricultural and forestry residues, municipal solid waste | No production (2025) |
| The Plurinational State of Bolivia | Sugarcane | Vegetable oils like macororo, palm, and soybean | Organic waste from urban areas, and potentially even wastewater sludge | Agricultural residues | N/A |
| Brazil | Sugarcane and corn | Soybean oil, animal fats (like tallow), cotton, and various oilseeds such as sunflower, rapeseed, and palm oil. | Sugarcane by-products like vinasse, animal manure from cattle and other livestock, municipal solid waste, and sewage sludge | Sugarcane bagasse, firewood and other agricultural residues | No production (2025) |
| Chile | No production (2025) | Crops like sunflower and rapeseed; second-generation options involve forestry residues and algae[a] | Agricultural and forestry waste, and organic waste from various industries. | Forest residues and agricultural by-products | No production (2025) |
| Colombia | Sugarcane | Palm oil | Agricultural and food waste, livestock manure | Oil palm waste, such as mesocarp fiber and palm kernel shell | No production (2025) |
| Ecuador | Sugarcane | Palm oil | Agricultural residues, animal waste, and the organic fraction of municipal solid waste | Agricultural and forestry residues | N/A |
| Paraguay | Sugarcane and maize | Soybeans | Agricultural waste, community waste, food industry waste, and household waste | Solid biomass, primarily wood fuels (firewood, charcoal, wood chips) | Range of biofuels, including: Hydrotreated HVO, synthetic paraffinic kerosene (SAF), and green naphtha. |
| Peru | Sugarcane | Crude palm oil | Agricultural residues, animal manure, municipal solid waste, and wastewater sludge. | Firewood, charcoal, and agricultural residues, | No production (2025) |

| | | | | | |
|---|---|---|---|---|---|
| Uruguay | Wood waste, sugarcane, sweet sorghum | Biomass from forestry, the beef industry, and edible oils | Agricultural and agro-industrial residues | Wood waste | Uruguay is in the process of establishing its first commercial-scale plant for producing SAF from biogas[a] |
| The Bolivarian Republic of Venezuela | Sugarcane, manioc (cassava), and rice | N/A | N/A | N/A | N/A |

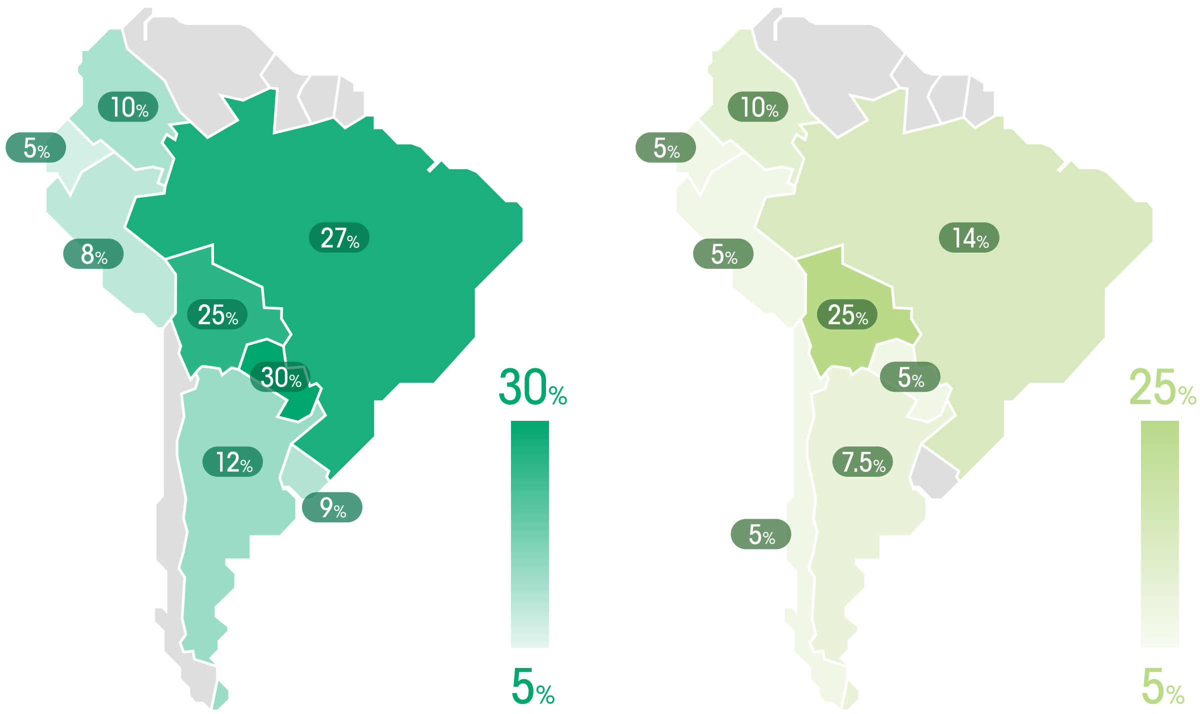
**Note:** [a] small production.

In 2023, energy generation from biomass in Brazil accounted for 4.6% of the country's total energy demand. This increase was primarily attributed to sugarcane bagasse, utilised in 422 plants with a combined capacity of 12 410 MW. Additionally, forest residues and biogas contributed 820 MW and 201 MW, respectively, illustrating the range of biomass sources used in the country, according to data from the Electric Energy Commercialization Chamber (CCEE, n.d.).

However, it is in the transport sector that bioenergy makes its most relevant contribution to decarbonisation in South America. The main support measures for the promotion of bioenergy in the transport sector include blending mandates, fiscal incentives and public financing. Figure 6.4 below shows blending mandates in South America.

Countries like Argentina, Brazil and Colombia dominate the region's production and consumption of biofuels such as ethanol and biodiesel, which are primarily used as blended fuels in road transport. Brazil stands out globally, accounting for around one-fifth of global biofuel production and meeting a quarter of its own road transport energy demand with biofuels – the highest share in the world (IEA, 2023c).

**Figure 6.4** Mandates in blending ratios for bioethanol (left) and biodiesel (right) across South America

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**Source:** (OLADE, 2025a)

Since the 1970s, Brazil has implemented a broad set of policies to support the sector, including the Pro-Alcohol (Pró-Álcool) programme, the National Biodiesel Program and, more recently, the RenovaBio policy. The latter includes mechanisms for life cycle assessment and commercialisation and predictability of the fuel market. It focuses on increasing biofuel consumption and its expansion in the Brazilian energy matrix, giving incentives to producers, and creating an open market of carbon-reduction credits called CBIO. As of 2024, Brazil had produced 9 billion litres of biodiesel, avoided 240 million tonnes of $CO_2$ emissions, and saved over USD 38 billion in diesel imports. In the same year, 47 million litres of ethanol and 75 million $m^3$ of biomethane were produced (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2025).

More recently, Brazil passed the Fuel of the Future Law (Law nº 14.993/2024), consolidating its role as a leader in low-carbon mobility. This law establishes multiple national programmes, including the Sustainable Aviation Fuel Program (ProBioQAV), Green Diesel Program (PNDV) and the Natural Gas Decarbonization Program, alongside updates to ethanol and biodiesel blending mandates. For instance, aviation fuel providers will be required to meet rising SAF targets starting in 2027, green diesel blending will begin with a mandatory share of up to 3%, and biomethane will be used to decarbonise the natural gas sector with targets starting in 2026. Ethanol and biodiesel blend limits were also revised, with flexibility for the National Energy Policy Council to adjust targets over time. These measures build on and integrate existing initiatives like RenovaBio, Rota 2030 and the Mover Program, and introduce a well-to-wheel emissions framework to align Brazil's fuels policy with global climate goals. As an example, Table 6.3 maps policies and fiscal benefits for bioenergy uses in Brazil and proposes additional measures.

**Table 6.3** Brazil's policy and financial support for bioenergy

| CURRENT REGULATIONS, DIRECTIVES OR PROPOSALS | ADDITIONAL MEASURES AND ACTIONS SUGGESTED |
|---|---|
| Blending mandate for bioethanol (AR, BO, BR, CO, EC, PY, PE and UY)<br>and biodiesel (AR, BO, BR, CL, CO, EC, PY and PE) | • Increase blend mandate<br>• Create blend mandates in countries where it still doesn´t exist<br>• Provide financial mechanisms for biorefineries<br>• Provide incentives for locally produced biofuels<br>• Establish a certification scheme for biofuels |
| Carbon Tax (AR, CL, CO and UY) | • Implement carbon tax schemes<br>• Harmonise regulations for cross-border energy exchange |
| Biofuels fiscal benefits/tax exemption (*e.g.*, CO, UY) | • Provide tax benefits/exemption for biofuels in countries where it still doesn´t exist<br>• Provide biofuel producers with fiscal incentives, including property and income tax exemption<br>• Provide tax incentives for biomass production to ensure sufficient feedstocks for production of more advanced fuels |
| Financing Mechanisms (*e.g.*, BR – BNDES) | • Provide direct support through environmental, social and governance credit for the biofuels sector |
| Cross-cutting policies | • Integrate related policies (such as agricultural and water), and diverse energy sources and technologies in comprehensive policies, and assisting developing countries<br>• Design policies that can harness flexibility |

Other countries in the region are also advancing bioenergy in different forms. The Plurinational State of Bolivia increased the ethanol and biodiesel content in fuels to reduce imports and mandated domestic sourcing of feedstocks. Paraguay adopted regulations to promote bioenergy from forest plantations and managed native forests, aiming to curb illegal logging and protect biodiversity. Support schemes in Argentina and Chile have incentivised the growth of biogas in power generation, while Brazil and Argentina are also advancing biomethane through transport-oriented programmes. As biofuels and biogas technologies mature, South American countries are leveraging their natural resource endowments to expand low-carbon fuel use and explore new export opportunities, particularly in sectors that are hard to decarbonise.

Regional co-operation is vital for advancing bioenergy. Many countries have developed significant bioenergy systems, and their economies co-exist with countries with similar natural and historical conditions that are still trying to promote bioenergy, without managing to overcome the barriers, prejudices and bottlenecks among the population and economic agents. By fostering dialogue among governments, industries and financial institutions, countries can share knowledge, overcome barriers and stimulate investment in sustainable bioenergy systems (IRENA, 2024c).

To harness the potentials stated above, countries must overcome several barriers. The most important of which is the absence of an adequate and stable legal and regulatory framework that provides sufficient certainty to define and stimulate demand for biofuels – such as national or subnational blending programmes – and for bioelectricity, through mechanisms like guaranteed capacity or energy purchase programmes. This lack of continuity in energy policy, coupled with legal uncertainty, increases investment risk. Without a favourable policy landscape that enables bioenergy to be marketed under sufficiently remunerative conditions, the sector's potential remains underutilised (IRENA, 2024c). Financial and economic barriers include fossil fuel subsidies in some countries, the high cost of bioenergy and limited access to affordable financing (IRENA, 2022c). A balanced tax framework is also crucial in shaping the competitiveness of biofuels, particularly through tax structures that account for the positive externalities associated with bioenergy.

# 07

# ENERGY TRANSITION PATHWAYS: **HYDROGEN AND DERIVATIVES**

## INSIGHTS AND RECOMMENDATIONS FOR THE ENERGY TRANSITION OF THE HYDROGEN AND DERIVATIVES SUPPLY

| INSIGHTS | RECOMMENDATIONS |
|---|---|
| ★ South America follows varied decarbonisation pathways for hydrogen, with several emerging initiatives across the region. Numerous pre-contracts for ammonia exports highlight its growing strategic importance in global clean energy markets. | ★ Establish multi-agency task forces to align hydrogen policy across sectors and ensure only targeted use of hydrogen is pursued in sectors and use cases where there is no effective alternative. |
| ★ Most countries in South America prioritise green hydrogen production, while some with natural gas resources (*e.g.*, Argentina) also consider low-carbon hydrogen options (green/blue/pink). Exports are often planned but not detailed; the DES expects ammonia to be the main export carrier which can be used without reconversion. | ★ Develop comprehensive national hydrogen road maps, including transportation infrastructure. Incentivise hydrogen hubs and demand aggregation mechanisms. Support procurement targets and compensation schemes. |
| ★ Regional co-operation is vital for a fair transition. Platforms such as H2LAC foster collaboration, but standards, carbon markets, and export partnerships remain underdeveloped. | ★ Promote carbon markets to support hydrogen revenues. Build international partnerships (*e.g.* memorandums of understanding with global ports). Harmonise technical standards across South America in line with the International Organization for Standardization. |
| ★ Hydrogen and derivatives production in IRENA's DES is projected to grow from around 250 PJ (2023) to over 2 900 PJ (2050), requiring approximately 1 300 TWh (over 25% of total regional electricity needs). Moreover, demand reaches 22 Mt hydrogen equivalent, around eight times 2023 levels. | ★ Launch competitive auctions and a regional investment platform to reduce risks and attract capital. Develop certification schemes (*e.g.* CertHiLAC). Invest in research and development (R&D), new applications and workforce reskilling. |
| ★ Large-scale hydrogen will need strong grid connections, storage, and integration with VREs. | ★ Strengthen grid planning and regulation for storage and system flexiblity. Incentivise integrated power–hydrogen projects. Expand hydrogen storage infrastructure. |
| ★ The DES requires a cumulative sum of around USD 100 billion in clean hydrogen investment by 2050, compared to USD 1.8 billion in PES, demonstrating the financing gap to meet current trade expectations. | ★ Provide subsidies and tax exemptions for first movers. Support electrolyser and fuel cell manufacturing. Incentivise green hydrogen for fertiliser production through tax credits. |

## 7.1 OVERVIEW OF HYDROGEN IMPLEMENTATION IN THE REGION

In recent years, a colour-coded system has been developed to classify hydrogen based on its energy source and, in some cases, its production process. The key types relevant to this report are:

- **Grey hydrogen**: Generated from fossil fuels—primarily natural gas and coal—without the use of CCS technologies.
- **Blue hydrogen**: Produced from fossil fuels, especially methane, with the application of CCUS to reduce emissions.
- **Green hydrogen**: A renewable form of hydrogen produced through electrolysis powered by clean energy sources such as wind, solar, geothermal, biomass, and small-scale hydropower.

South America is well-positioned to meet the estimated global demand for clean hydrogen[44] and its derivatives, both domestically and through exports (IRENA, 2022d). The region offers ideal conditions for **green** hydrogen production, with abundant wind, solar, geothermal and hydropower resources, and also has proven natural gas reserves for **blue** hydrogen. Its strategic geographic location also facilitates advantageous access to key international markets in Europe, Asia and North America.

Several countries have already released national roadmaps (referenced in Chapter 7, section 7.3 Policies for hydrogen production and trade) outlining plans to produce hydrogen both for domestic use and export in support of global decarbonisation goals. While the majority of countries focus exclusively on green hydrogen production and trade, Argentina (as well as Colombia) adopts a broader definition of clean hydrogen that encompasses blue hydrogen, leveraging its natural gas reserves and established expertise in extraction and industrial conversion processes, as well as pink hydrogen, given that Argentina operates several nuclear power plants. This aligns with IRENA's efforts to analyse the region's unique conditions and underscore the necessity for tailored policy frameworks that reflect its specific natural resources, recognizing that a one-size-fits-all global strategy would be suboptimal.

The development of a hydrogen market in the region presents multiple advantages. Smaller energy markets with limited fossil fuel reserves (such as Uruguay) can leverage their abundant renewable energy resources to establish themselves as key producers and exporters of green hydrogen and related derivatives. Furthermore, the expansion of green hydrogen production will directly stimulate the growth of renewable energy capacities, particularly wind and solar, which are essential for its generation. For traditional oil and gas producers like Argentina, green hydrogen presents an opportunity for economic diversification, while pink and blue hydrogen offer a transitional solution that supports emissions reduction as renewable-based hydrogen scales up.

Today, hydrogen is primarily used as an industrial feedstock, especially in the production of ammonia and methanol, in oil refining processes, and as part of mixed gases for steel manufacturing and industrial heat generation. In 2023, the demand for hydrogen and its derivatives was at a level equivalent to 3 $MtH_2$ (around 340 PJ), with nearly all of it derived from fossil fuels.

Hydrogen and its derivatives provide a viable path to decarbonise hard-to-abate sectors such as heavy industry, long-haul transport, shipping, and aviation, as noted in IRENA's *World Energy Transitions Outlook* (IRENA, 2024a). While electrification is more efficient and cost-effective for sectors like road transport and low- to mid-temperature heating, hydrogen is better suited to applications where electrification is challenging (IRENA, 2022d).

*[44] Certain countries in the South American region classify pink hydrogen as a low-emission option, as it refers to production using electricity generated from nuclear power plants.*

Depending on hydrogen's end use, it may be more cost-effective to convert it into a commodity before transport, rather than shipping it directly (IRENA, 2022d). These carriers typically have higher energy density, enabling greater transport capacity and reducing costs. This approach can be particularly attractive for products like ammonia (used both as a chemical feedstock and as a fuel), methanol, and synthetic fuels. For the latter, reconversion to hydrogen is not required, as these commodities are used in their transported form. The production of hydrogen-derived commodities will depend not only on cost differences, including production and transport, but also on factors such as industry maturity, local labour availability, technological expertise, industrial and trade policies, GHG reduction targets, renewable resource availability, and the scale of the renewable energy sector.

For hydrogen trade to scale effectively, several interdependent dimensions must align:

- **Market Creation:** Establishing a functioning market requires demand generation, transparency, and collaboration between producers and end users
- **Regulation:** This dimension considers energy policies with ambitious decarbonisation targets (conditions under which hydrogen becomes systemically viable) as well as the presence of dedicated hydrogen policies, and the share of renewables in the electricity mix.
- **Certification**: An internationally harmonized certification scheme is needed to verify production methods and emissions (Gischler *et al.*, 2023). The certification should encompass process efficiency, sustainability, quality standards, and social considerations.
- **Financing**: Substantial investment is needed, particularly in upstream renewable energy capacity and supporting infrastructure for both domestic use and international trade. Access to financing is therefore crucial, whether from national financial institutions or multinational organisations.
- **Infrastructure**: This factor considers whether the exporting country has an established hydrogen industry, experience with renewable hydrogen, and the scale and nature of existing projects. It also includes the availability of supporting infrastructure, such as gas networks that could be used to reduce transport costs, suitable underground storage near production sites, experience with gas liquefaction, and well-connected ports with the capacity and facilities for hydrogen handling (IRENA, 2022d).

Coordinated regional policy efforts are key to complementing national strategies and enhancing Latin America and the Caribbean's (LAC's) position in the global green hydrogen market. Among the initiatives focused on hydrogen and its derivatives, **H2LAC** plays a leading role. Funded by the EU's Euroclima Programme, GIZ, the World Bank and ECLAC, H2LAC is a collaborative platform promoting the development of green hydrogen and its derivatives in LAC. The platform aims to leverage green hydrogen's potential to tackle climate challenges, drive sustainable transformation, and foster economic growth across the region. The platform's Atlas H2LAC serves as a valuable tool for visualizing hydrogen-related strategies, national plans, ongoing projects, and trade activities across all countries in the region.

Several countries in the region have established national associations to promote hydrogen development. Argentina is home to the H2AR Consortium (Consorcio H2AR), while Brazil has the Brazilian Green Hydrogen Industry Association (Associação Brasileira da Indústria de Hidrogênio Verde [ABIHV]). Chile is represented by Chilean Hydrogen Association (H2 Chile – Asociación Chilena de Hidrógeno), Uruguay by the Uruguayan Hydrogen Association (Asociación Uruguaya de Hidrógeno [AUH]) and Paraguay by the Paraguayan Hydrogen Association (Asociación Paraguaya de Hidrógeno). Additionally, Peru has H2 Peru – Peruvian Hydrogen Association (H2 Peru – Asociación Peruana de Hidrógeno) and Colombia is represented by the Colombian Hydrogen Association (Asociación Hidrógeno Colombia). Several of these associations are members of the LAC Clean Hydrogen Action Alliance, established in the context of COP26. This association seeks to unite and co-ordinate regional stakeholders involved in low-emission hydrogen development.

This chapter presents the main findings and insights from the analysis of hydrogen and its derivatives in South America, addressing key questions such as:

- What is the role of hydrogen in regional end-use decarbonisation?
- How are countries in the region developing strategies for integrating hydrogen into their energy systems while also shaping frameworks for hydrogen's trade and commercialisation at both the regional and global levels?
- To what extent are South American countries collaborating to establish a co-ordinated outline for integrated energy planning and policy alignment?
- How does hydrogen production influence overall electricity consumption across the region?

## 7.2 ROADMAPS FOR HYDROGEN PRODUCTION AND TRADE

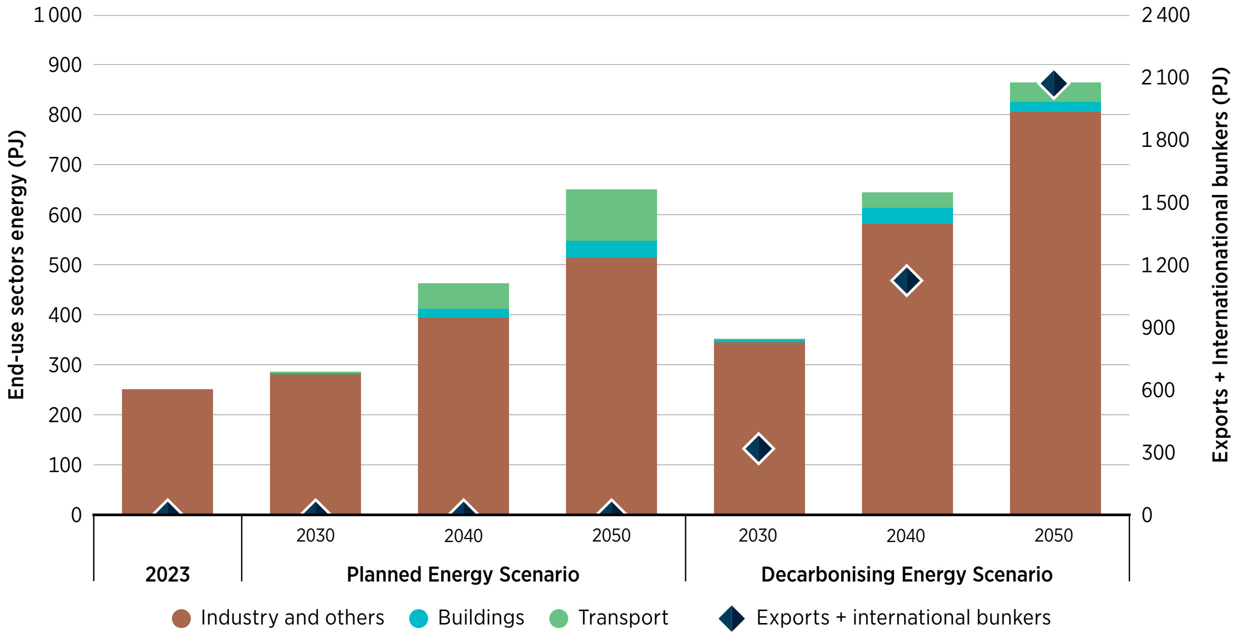
This section examines the requirements for expanding clean hydrogen production, which will play a crucial role in the future energy system. As global economies move toward carbon neutrality, competitive hydrogen and hydrogen-derived synthetic fuels (such as ammonia and methanol) emerge as key elements of the energy mix.

Two primary strategies are being pursued in the region to reduce carbon emissions in domestic consumption of gases. Several countries (including Argentina, Chile and Colombia) are focusing on mixing or replacing natural gas with hydrogen, either by blending it into existing natural gas networks or using it as a thermal energy carrier in various processes. In contrast, Brazil is not prioritizing hydrogen; instead, it is turning to biomethane, with plans to begin blending it into its natural gas grid as early as 2026. In the PES, clean hydrogen adoption remains limited, with Argentina as the only country planning to blend hydrogen into the natural gas grid—starting as early as 2030.

Achieving the full potential of hydrogen in a decarbonising scenario requires a coordinated approach across infrastructure, policy, and technology. Significant investment is needed in production facilities, storage, and pipelines, alongside international co-operation and trade agreements to build a global hydrogen market. Governments need to support early adoption to stimulate demand, while certification schemes are crucial to ensure hydrogen's sustainability and prevent emissions leakage (IRENA, 2022d). In alignment with their renewable energy and water availability, several countries are positioning themselves as regional hubs for green hydrogen. Within the DES framework, this ambition is reflected in two primary pathways: direct use of hydrogen in end-uses and the export of ammonia for use in international maritime bunkering. Ammonia conversion from hydrogen is a well-established, large-scale commercial process supported by existing infrastructure — including ports, ships, and storage facilities. It can be used directly as a fuel or feedstock, avoiding the high energy cost of reconversion to hydrogen.

In the PES by 2050, hydrogen and its derivatives demand are anticipated to reach around 0.7 EJ (5.4 $MtH_2eq$). Under the DES, demand is expected to increase significantly, reaching 2.9 EJ (24 $MtH_2eq$) by 2050. Clean hydrogen (blue and green hydrogen) is expected to play a key role in the industrial sector, particularly in green steel production using direct reduced iron and as a feedstock in chemical and petrochemical processes. In transport, clean hydrogen and its derivatives—such as methanol and ammonia—will support harder-to-electrify modes. Furthermore, IRENA's DES also considers certain amount of hydrogen to be traded between continents primarily by ship, mainly in the form of ammonia, which is typically used without being converted back to hydrogen. As illustrated in Figure 7.1, exports and international bunker use together represent over 75% of hydrogen and derivatives demand by 2050, underscoring their significance for the region.

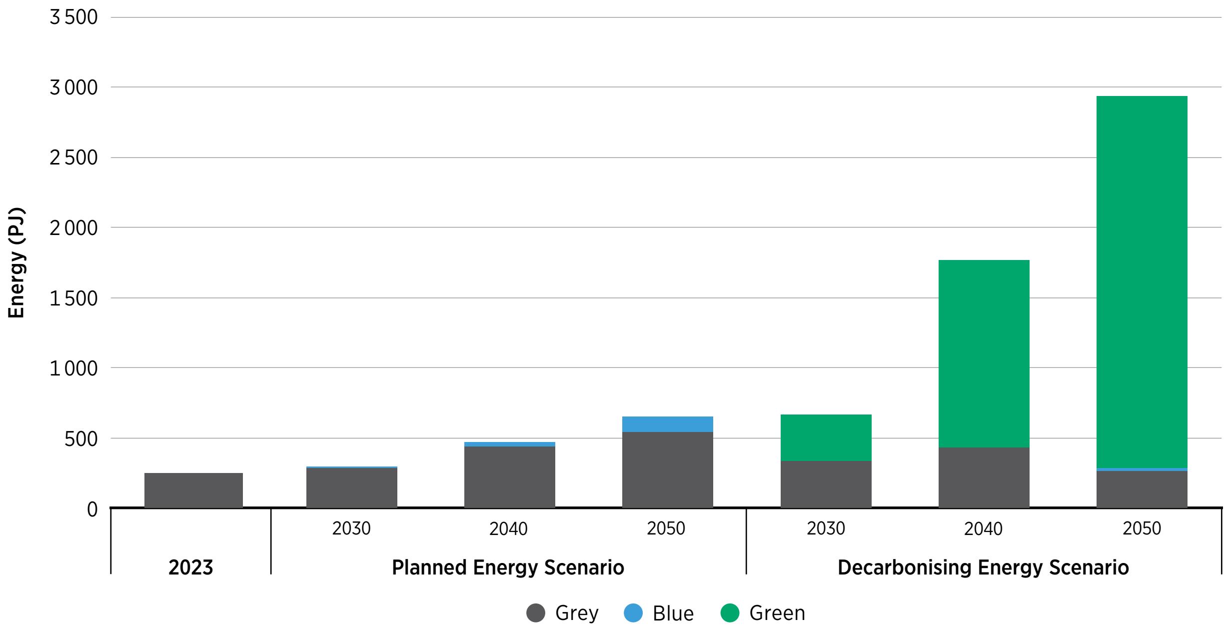
**Figure 7.1** Hydrogen and derivatives demand (PJ) in South America under the PES and DES, by end-use sectors, 2023-2050




**Note:** Derivatives refer to ammonia.

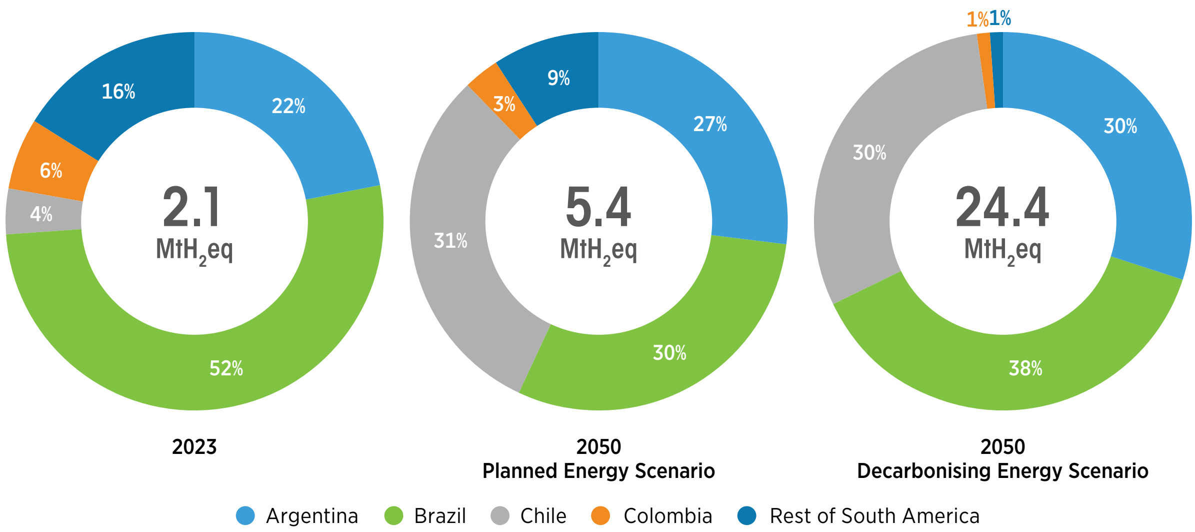
In terms of production, clean hydrogen and derivatives in PES could reach nearly 0.11 EJ (0.9 $MtH_2eq$) by 2050, while under IRENA's DES, clean hydrogen and derivatives scales up more rapidly reaching around 0.33 EJ (2.8 Mt) by 2030 and 2.7 EJ (22 Mt) by 2050. The projected hydrogen mix varies depending on the scenario (Figure 7.2): by 2050, the PES anticipates over 15% blue hydrogen with the rest derived from fossil fuels, whereas the DES envisions 90% green hydrogen, 1% blue with the remaining being fossil-based.

**Figure 7.2** Hydrogen and derivatives production (PJ) in South America under the PES and DES, by hydrogen type, 2023-2050




**Note:** Hydrogen derivatives refer to ammonia for the South American region. Blue hydrogen was only included in Argentina's projections, aligning with the national strategies in force by the time of the analysis phase.

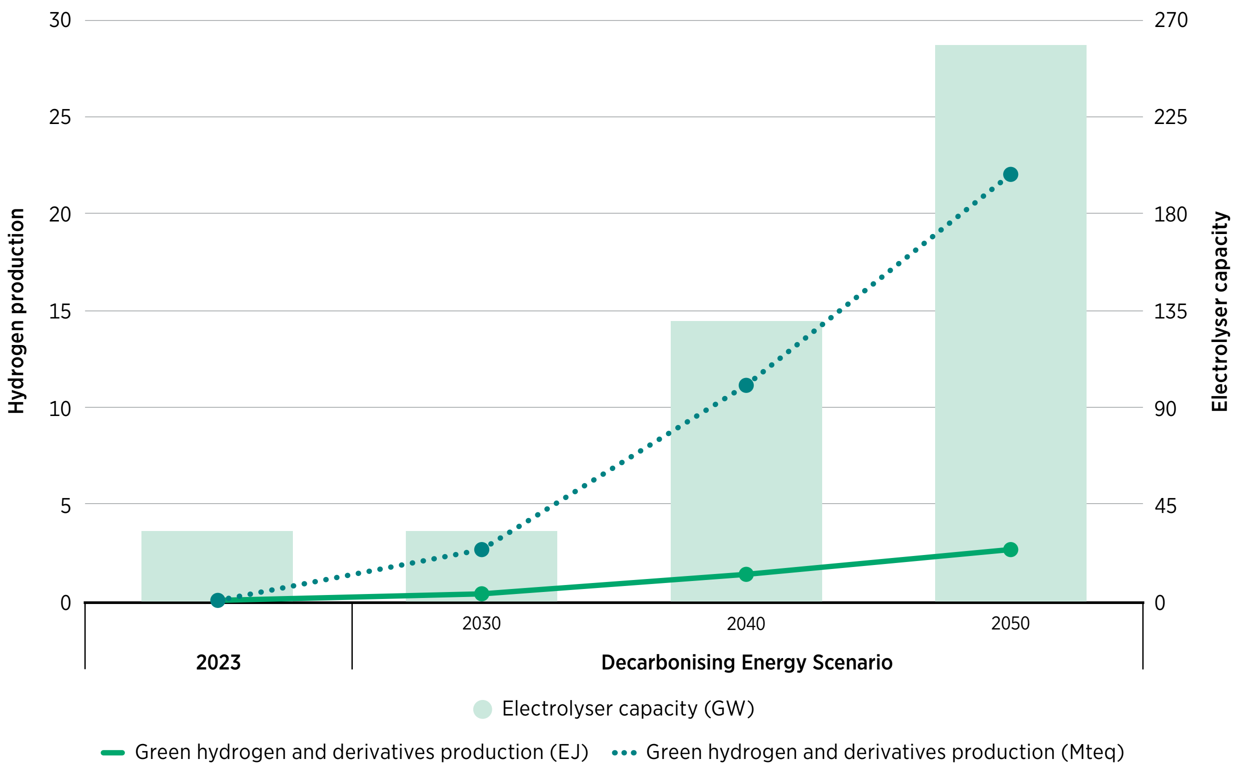
**Figure 7.3** Hydrogen and derivatives production ($MtH_2eq$) in selected South American countries in 2023, and under the PES and DES by 2050




**Note:** HAD = Hydrogen and derivatives

To reach the target in the DES, South America's green hydrogen electrolyser capacity should scale to around 32 GW by 2030 and almost 260 GW by 2050 (Figure 7.4). Hydrogen production could require around 1 300 TWh, over 25% of the region's electricity demand by 2050. Integrated planning will be essential to develop a bankable pipeline of renewable energy projects and electrolysers to meet this growing demand.

**Figure 7.4** Green hydrogen production and electrolyser capacity (GW) under the DES, 2023-2050



As noted, limited access to affordable financing remains a key barrier to clean hydrogen development in the region. Financing will require a blend of public grants, government guarantees, tax incentives, long-term off-take agreements, project finance, equity, and concessional funding. Crucially, subsidies and tax benefits should span the entire value chain, from renewable energy generation to hydrogen production, derivatives, and associated transport and storage infrastructure (Gischler *et al.*, 2023).

To help address this, institutions like the IDB provide funding to support sustainable energy initiatives: in 2024, the IDB approved two key projects: "*Support for the Acceleration of Clean Ammonia Development in LAC*", focused on advancing hydrogen derivative policies in Brazil, Chile and Colombia; and "Renewable Energy Integration – Support to Green Hydrogen Projects" in Colombia, aimed at providing technical assistance and fostering green hydrogen development. Moreover, USD 1.65 million in World Bank funding had been approved for green/renewable hydrogen loans as of 2023 (ESMAP, *et al.*, 2024).

**South America has significant potential to become a hydrogen hub, with an estimated 6 EJ to 60 EJ of low-cost green hydrogen (under USD 2/kg) producible in the region** (Gischler *et al.*, 2023). Green hydrogen currently costs two to three times more than blue hydrogen, though blue hydrogen cost estimates remain uncertain due to the lack of large-scale facilities. The primary barrier to green hydrogen production is its high cost, largely driven by electricity — which can account for up to 75% of production costs — and electrolyser equipment, with stacks representing 50–60% of total capital expenditure. However, declining renewable energy prices and technological improvements in electrolysers could make green hydrogen cost-competitive by 2030 or earlier.

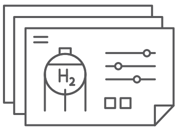
Although many strategies lack cost analyses for hydrogen derivatives, a recent IDB-funded study estimates the average levelised cost of ammonia (LCOA) at around USD 990/t by 2030, falling below USD 800/t by 2040 in most South American countries (Gischler *et al.*, 2023). The study highlights that countries with existing ammonia and methanol infrastructure are well-positioned to remain competitive long-term, enabling them to export hydrogen as ammonia.

In terms of investments needs for infrastructure, estimations in the PES account for USD 1.8 billion from 2025 to 2050, whereas the DES calls for approximately USD 100 billion by 2050, underscoring the urgent need to scale up efforts.

From a global perspective, South America is set to become one of the most-competitive regions for green hydrogen production, positioning it as a strong supplier for export markets such as Europe. According to modelling, by 2050, South America is projected to produce green hydrogen at highly competitive costs, ranging from about USD 1.3–2.0/kg across major producers such as Argentina, Brazil, and Chile. When converted to ammonia and shipped to Europe, total delivered costs could reach roughly USD 2.5–3.0/kg.[45] This is within the range of Europe's expected domestic production costs, making South American hydrogen exports economically attractive for supporting Europe's low-carbon transition and energy security (Hydrogen Europe, 2024; Janssen *et al.*, 2022; PwC, 2024).

[45] *Delivered cost assumes an additional USD 1.2–1.4 per kg $H_2$ for ammonia conversion, storage, and shipping from South America to Europe (based on large-scale export routes and 2050 technology and freight cost projections).*

**Table 7.1** Clean hydrogen and derivatives supply and consumption KPIs for achieving the PES and DES, 2023-2050




| | HISTORICAL | PLANNED ENERGY SCENARIO | | | DECARBONISING ENERGY SCENARIO | | |
|---|---|---|---|---|---|---|---|
| | 2023 | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **KPI. 05 CLEAN HYDROGEN AND DERIVATIVES** | | | | | | | |
| Clean hydrogen and derivatives production (PJ) | 0 | 0 | 28 | 110 | 331 | 1 338 | 2 671 |
| Clean hydrogen and derivatives production ($MtH_2eq$) | 0 | 0 | 0.2 | 0.9 | 2.8 | 11 | 22 |
| Clean hydrogen share in TFEC (%) | 0% | 0.08% | 0.54% | 0.9% | 0.13% | 0.8% | 1.1% |
| Clean hydrogen share in transport TFEC (%) | 0% | 0% | 0.5% | 0.9% | 0% | 0.4% | 0.6% |
| Clean hydrogen share in industry TFEC (%) | 0% | 0.2% | 0.8% | 1.2% | 0.3% | 1.2% | 1.8% |
| Clean hydrogen share in buildings TFEC (%) | 0% | 0% | 0.3% | 0.5% | 0.1% | 0.7% | 0.4% |
| **TOTAL SYSTEM COSTS** | | | | | | | |
| Cumulative - investment (2024 USD billion) | - | 0.01 | 0.6 | 1.2 | 12 | 39 | 50 |

**Notes:** "Total system costs" for clean hydrogen and derivatives include electrolysers and the supporting infrastructure needed to produce blue hydrogen and green ammonia. The value in 2030 refers to the cumulative amount for the period 2025-2030. The value in 2040 accounts for the period 2031-2040, and the value in 2050 compiles the period 2041-2050; $MtH_2eq$ = million tonnes hydrogen equivalent; PJ = petajoules; TFEC = total final energy consumption.

By 2050, global hydrogen consumption is projected to reach around 523 Mt, with the EU accounting for about 36 $MtH_2eq$. However, most major regions are aiming to meet their own demand through domestic production, reducing the scope for large-scale international trade. Europe and a range of other countries and regions foresee imports mainly to complement domestic supply and ensure energy security rather than to rely on external sources (IRENA, 2024a, 2025e).

In this context, South America's competitiveness in green hydrogen production positions it well for niche export opportunities, such as supplying ammonia for bunkering and limited industrial uses. Yet, the global market for long-distance hydrogen trade is expected to remain relatively modest, as regional self-sufficiency and local value chain development dominate national hydrogen strategies.

## 7.3 POLICIES FOR HYDROGEN PRODUCTION AND TRADE

Almost all countries in South America have presented plans for a hydrogen economy (see Table 7.2), as they are racing to become leaders or hubs in the region. A more co-ordinated approach among countries could tap the best available natural resources, facilitate access to cheaper finance, support developing a local supply chain and help the development of the infrastructure planning to drain production to the market.

With respect to types of hydrogen, while Argentina and Colombia include blue hydrogen from coal and natural gas as a transition strategy, Brazil, Chile, Colombia and Uruguay are more focused on green hydrogen. Among all initiatives, Uruguay seems to be far more advanced in its plans, with a very competitive target for the levelised cost of hydrogen of around USD 1.2/kg to USD 1.4/kg.

**Table 7.2** Country initiatives for the hydrogen economy in South America

| COUNTRY | COUNTRY INCENTIVES | |
|---|---|---|
| Argentina | **REGULATION** | National Hydrogen Strategy (2022) |
| | **INCENTIVES** | Since 2021, Argentina has been part of the international PtX Pathways initiative, led by the German government, to promote sustainable hydrogen markets. In 2023, the government of Argentina created an Intersectoral Hydrogen Table (la Mesa Interministerial del Hidrógeno), as a space for public-private consultation to explore hydrogen opportunities in Argentina. |
| | **INVESTMENTS/ PARTNERSHIPS** | Fortescue will invest USD 8.4 billion in the Argentinian province of Rio Negro |
| Brazil | **REGULATION** | National Hydrogen Program – 2022 Law 14.948/2024 –institutes the legal framework for low-carbon emission hydrogen, including the National Hydrogen Policy for Low Carbon Emissions that institutes the REHIDRO and creates the Low Carbon Emission Hydrogen Development Program |
| | **INCENTIVES** | The Low Carbon Emission Hydrogen Development Program grants economic subsidies for low-carbon hydrogen and its derivatives for a maximum period of ten years. Subsidies with a total value of BRL 18.3 billion (USD 3.4 billion) have been approved in the form of a tax credit to be granted by the federal government to companies benefiting from REHIDRO. |
| | **PROJECTS** | In recent years, dozens of green hydrogen projects in Brazil have been announced. It is estimated that they will add up around USD 40 billion in investments to produce 7.7 Mt/ year of green hydrogen. Currently there are around 15 small-scale pilot plants, most focused on R&D. |

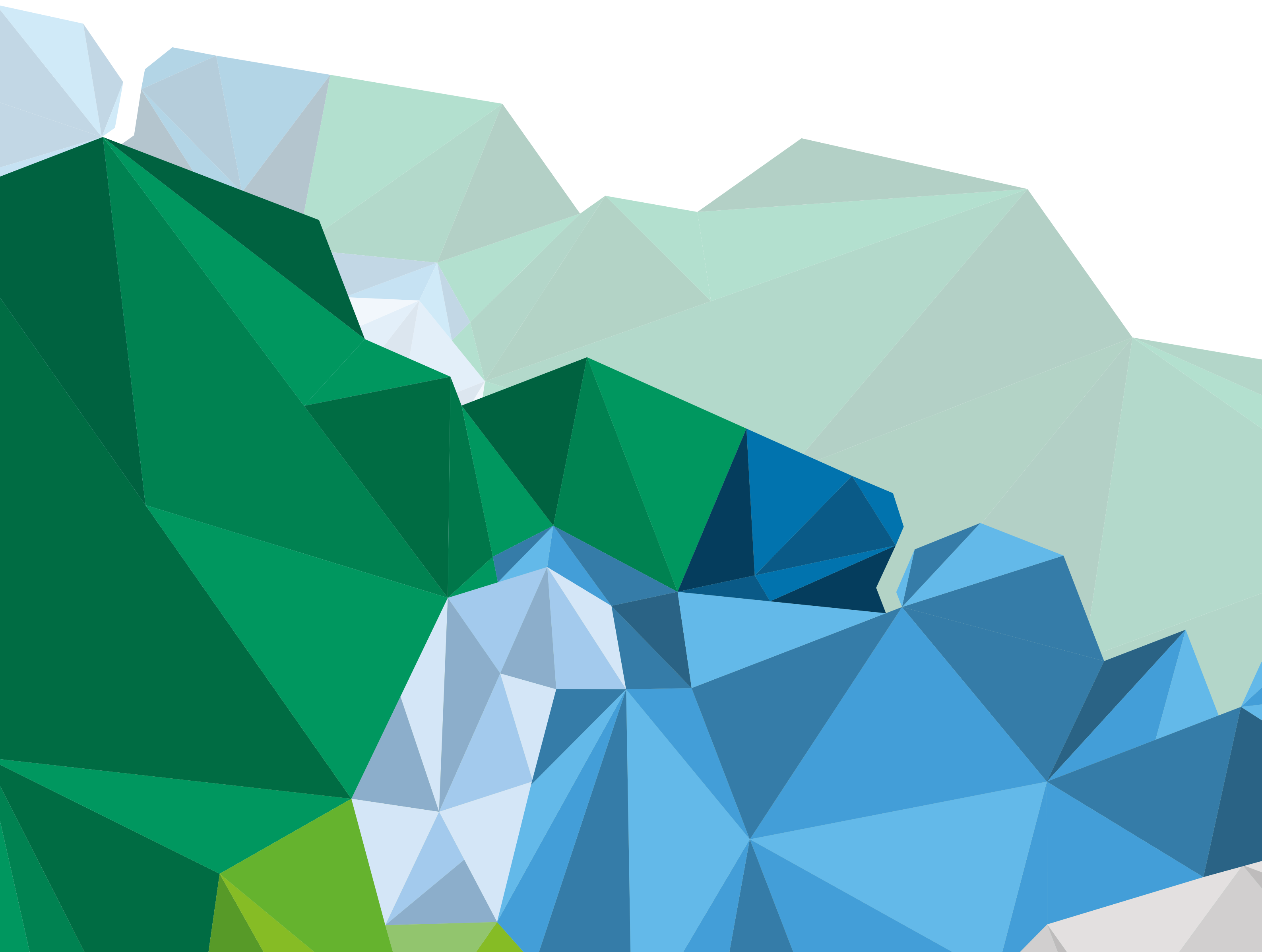
| | | |
|---|---|---|
| Colombia | **INCENTIVES** | The Ministry of Mines and Energy published a draft decree establishing that green hydrogen producers who are supplied with non-conventional renewable energy sources by self-generators or marginal producers will be exempt from charges for transportation and distribution of electric energy. |
| | **PROJECTS** | Currently, Colombia has 28 hydrogen projects in development. Seven are already in the testing phase, with an estimated total installed electrolysis capacity of ~12.8GW. Two demonstration projects to produce green hydrogen and its use in refining and grid blending became operational in 2022, and Ecopetrol announced plans for the development of two projects to create low-emission hydrogen production capacities at industrial scale. |
| | **INVESTMENTS/ PARTNERSHIPS** | Colombia has been active in international dialogues with the objective of positioning itself as a potential exporter for the largest markets (Japan, Korea and Europe). The government has signed a memorandum of understanding with the Port of Rotterdam, which it aims to replicate with other European ports, and is working to establish co-operation agreements with Australia, Chile and Germany. Colombia is currently exploring its accession to the International Partnership of Hydrogen and Fuel Cells in the Energy. |
| Chile | **REGULATION** | National Green Hydrogen Strategy, (2024); Green Hydrogen Action Plan (2024) |
| | **INVESTMENTS/ PARTNERSHIPS** | In 2021, Chile's state development office pledged USD 50 million in grants to six green hydrogen projects. These six projects, the first to be supported under the country's green hydrogen strategy, are expected to attract a total of USD 1 billion in investment and to develop an electrolyser capacity of 388 MW producing more than 45 000 t green hydrogen annually. The Chilean development office signed additional funding agreements with GNL Quintero, CAP and Air Liquide for their green hydrogen initiatives in 2022. In 2023, the World Bank approved its first loan to promote green hydrogen: USD 150 million for Chile´s green growth, and energy transition, supporting its commitment to carbon neutrality by 2050. |
| Peru | **REGULATION** | Law for the Promotion of Green Hydrogen No. 31992/2024 |
| | **PROJECTS** | The first Peruvian green hydrogen project started operations in January 2024 in a solar plant located in Chilca, in the south of Lima. |
| Uruguay | **REGULATION** | Green Hydrogen Roadmap (2022); H2U Program (Presidential Resolution 294/2022); Law No. 16.906 |
| | **PROJECTS** | HIF Global; HIF Paysandú e-Fuels; H24U pilot |
| | **INVESTMENTS/ PARTNERSHIPS** | Uruguay worked with the Port of Rotterdam on preliminary studies to identify Uruguay's potential as a producer and exporter of green hydrogen and derivatives to Europe. The New Green Hydrogen Sector Fund promotes the development of the production of green hydrogen and derivatives, financing research, innovation and training projects. The plan will include non-refundable monetary support of USD 10 million from the government, which will be awarded and distributed within a period of no more than ten years from the start of operations. HIF Global plans to invest USD 6 billion in green hydrogen. |

**Source:** (ABIHV, n.d.; CAP, n.d.; Misculin and Agustin Geist, 2021; S&P Global Commodity Insights, 2021).

Due to the region's high potential for competitive renewable generation, many South American countries have already developed hydrogen strategies with ambitious roadmaps in terms of volumes and price competitiveness. In addition, Argentina, Brazil, Chile, Colombia and Uruguay now have regulatory frameworks in place. These strategies and frameworks indicate that these countries are willing to lead a regional market, create new jobs and attract foreign investments. However, despite these strategic developments and the great renewable generation potential in South America, renewable projects still face challenges such as a lack of competitiveness and absence of long-term offtake contracts, which are essential for securing project financing.

# 08

# SOCIO-ECONOMIC IMPACTS OF SOUTH AMERICA'S ENERGY TRANSITION



In addition to being a technological change, South America's energy transition offers an opportunity for development. Drawing on the DES, this chapter's analysis captures how energy system transformations can influence economic growth and employment evolution at both the regional and national levels. To do so, the DES is compared to the PES, which reflects current policies and commitments. This section examines the macroeconomic implications of the transition for South America, highlighting:

- overall GDP, employment impacts and growth trends
- underlying drivers of economic and employment trends
- insights into selected countries such as Argentina, Brazil and Colombia, as well as the rest of South America.

The analysis builds on these insights by identifying the key drivers (investment, trade, household consumption and government spending), providing an evidence-based foundation for policy makers to leverage the socio-economic benefits of the transition, while anticipating and managing its associated risks.

## 8.1 INTRODUCTION

The socio-economic analysis is conducted using a macro-econometric model (E3ME)[46] that integrates the energy system and global economies into a single quantitative framework. The model sheds light on the trade-offs between economic prosperity and employment, while examining welfare aspects, including the distributional implications of these policy choices. Policy makers need to be aware of how such choices will affect people's well-being and overall welfare and of the potential gaps and hurdles that could affect progress. This report aims to provide valuable insights and recommendations to South American policy makers, ensuring that the region's transition to a low-carbon economy is both just and equitable, fostering job creation and reducing inequalities.

This chapter discusses the socio-economic differences between the PES and DES in South America, using the energy mixes and related investment, based on the REmap Activity Tool, as exogenous inputs. Under the PES, South America's economy is expected to experience economic growth. The region's real GDP is projected to increase at a compound annual growth rate (CAGR) of around 2.4% between 2023 and 2050. Economy-wide employment is also expected to increase at a CAGR of 0.2% over the same period. Additionally, the South American population is projected to grow at a CAGR of 0.4% over the 2023-2050 period (Table 8.1), reaching over 490 million in 2050. The analysis explores the socio-economic footprint outcomes resulting from several policy assumptions and measures such as carbon pricing, international collaboration, subsidies, progressive fiscal regimes to address distributional aspects, investments in public infrastructure and spending on social initiatives – to support a just and inclusive transition.

[46] *The E3ME global macro econometric model (www.e3me.com) is used for the assessment of socio-economic impacts. Energy mixes and related investment, based on the REmap Activity Tool, are used as exogenous inputs for each scenario, as well as climate- and transition-related policies.*

**Table 8.1** GDP, labour force and population growth projections under the PES

| CAGR (%) | 2023-2030 | 2031-2040 | 2041-2050 |
|---|---|---|---|
| GDP | 2.1% | 2.4% | 2.4% |
| Economy-wide employment | 0.5% | 0.3% | 0.0% |
| Population (million) | 0.7% | 0.4% | 0.2% |

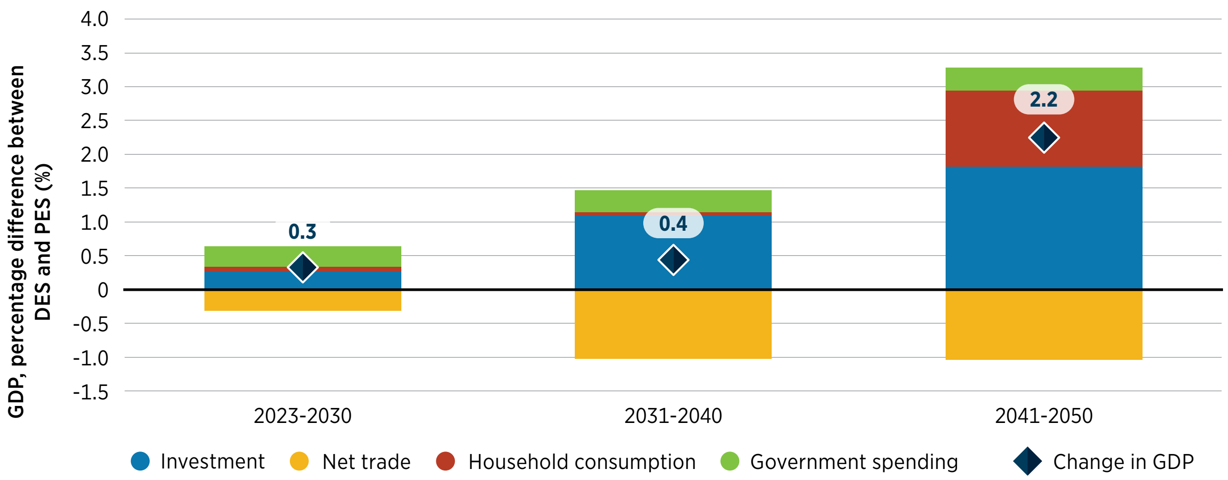
**Note:** CAGR= compound annual growth rate.

The next sections delve into the macroeconomic findings to analyse the socio-economic impacts of the energy transition in South America until 2050. An analysis of how this change might affect GDP (Chapter 8, Section 2), job creation (Chapter 8, Section 3) and people's welfare (Chapter 8, Section 4) is provided. Finally, Chapter 8, Section 5 will discuss industrial and circular economy policies. This chapter not only explores the socio-economic impacts of the energy transition but also highlights its connection to prevailing trends, providing a comprehensive analysis for ensuring a just and inclusive energy transition.

## 8.2 ECONOMIC IMPACTS, AS MEASURED BY GDP

The adoption of renewables and improvements in energy efficiency, combined with progressive policies, holds great promise for boosting global socio-economic indicators as the energy transition progresses. Under the DES, South America is expected to improve its GDP by an additional 1.1% on an annual average over the 2023-2050 period compared with the PES. South America's economy would add over USD 2.5 trillion[47] under the DES compared to the PES over the same period (*i.e.* equivalent to an annual average of around USD 89.6 billion). South America's economy would progressively perform better throughout the transition period (*i.e.* 2023-2050), increasing from 0.3% on an annual average in the first decade (*i.e.* 2023-2030) and 0.4% in the second decade (*i.e.* 2031-2040), before reaching a peak of 2.2% in GDP difference between the DES and PES (Figure 8.1).

**Figure 8.1** South America's GDP, percentage difference between the DES and PES by driver, 2023-2050




[47] *In 2024 USD.*

The macroeconomic benefits observed in the DES are mostly accrued by domestic investment, structural changes in consumption and specific government spending, although trade remains a persistent constraint on output. **Investment** emerges as the main driver for the increase in GDP changes under the DES compared to the PES (Figure 8.1). The driver is steady in the first decade of the transition (*i.e.* 2023-2030), while it spikes in the second and third decades, reaching an annual average of around USD 91 billion throughout the transition period. Such investments would also generate increased demand in various economic sectors, including equipment manufacturing, construction, and services like retail and business. Investment in fossil fuel sectors in the region falls in the DES compared to the PES, most rapidly in the last two decades. This effect is substantial: the sector loses investment by an annual average of around USD 90 million through to 2030, over USD 412 million between 2031 and 2040, and USD 360 million between 2041 and 2050 under the DES compared to the PES, as fossil fuel-based power capacity is almost completely phased out in the DES in 2050. The negative effect of the decrease in fossil fuel supply investment would be offset throughout the transition by the increasing positive effects of transition-related investment, which includes investment in renewables, energy efficiency, electrification, grids and energy flexibility. These effects become even more pronounced as capital deployment increases and the transformation of energy systems speeds up over time.

The role of **household consumption** in GDP difference between the DES and PES is also highlighted as significant and growing further beyond 2030. Higher employment due to increasing investment stimulus, and lower energy expenditures due to rapid deployment of renewables between 2030 and 2050 in the region, would stimulate demand across sectors, such as food, drink and tobacco within the basic manufacturing aggregate; distribution and retail; and public and personal services as a direct result of shifting consumption habits. Fiscal reallocation from fossil fuel subsidies, tax revenues and carbon-related revenues via revenue recycling[48] support the positive contributions of **government spending** through social-directed payments to deal with domestic distributional issues, *i.e.* providing support to the lower quintile of the population and transition-related expansion.

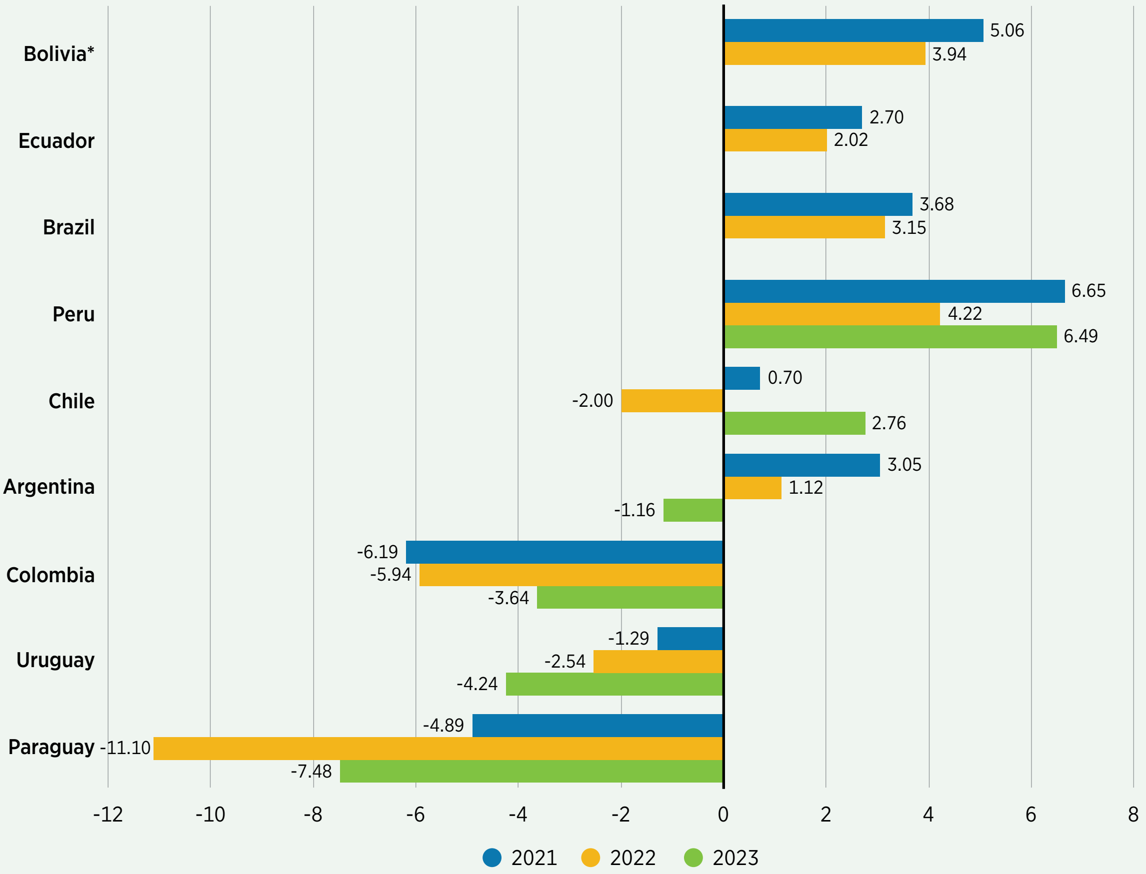
In contrast, **net trade** has a negative effect on GDP difference between the DES and the PES over the entire transition period. Trade impacts on GDP difference are shaped by changes in fuel trade and responses to trade on other commodities. Net fuel trade negatively impacts the regional economy throughout the entire forecast period. Under the DES, lower consumption of manufactured fuels leads to reduced fuel export revenues (Box 4). This negative effect dissipates as consumption of manufactured fuels already tapers off through to 2050 under the PES. The macroeconomic benefits of decarbonisation could be weakened in fossil-dependent economies within the region. In addition, the DES affects non-fuel trade by altering price-driven competitiveness and trade dynamics, with global changes in non-fuel trade expected to be negative throughout the forecast period. This underscores the need for forward-looking industrial and trade diversification strategies.

[48] *From a modelling perspective, revenue recycling is not only a policy instrument for addressing distributional issues in the context of scenarios; it is also a way to avoid assuming that in the case where large investments must be made to finance the transition, governments would increase borrowing without any quantified impact on the economy and society.*

## Box 8.1 Non-energy and Energy related trade trends in South America

Trade balances from 2021 to 2023 reflected mixed trends for South America. Despite some countries (like Brazil and Peru) maintaining strong trade surpluses, others (such as Argentina, the Plurinational State of Bolivia and Colombia) saw significant export declines in 2023, which aligns with their fluctuating trade balances. Argentina's export drop in 2023, set at -25.5%, corresponds with its shift from surplus to deficit. However, the strong export rebound projected for 2024, particularly for Argentina, Peru, Ecuador and Uruguay, suggests potential improvements in trade balances going forward, although Brazil and Paraguay's negative export growth may pose challenges for their trade surpluses (IDB, 2025) (Figure 8.2).

**Figure 8.2** Trade balance of selected South American countries as a percentage of GDP in 2021, 2022 and 2023

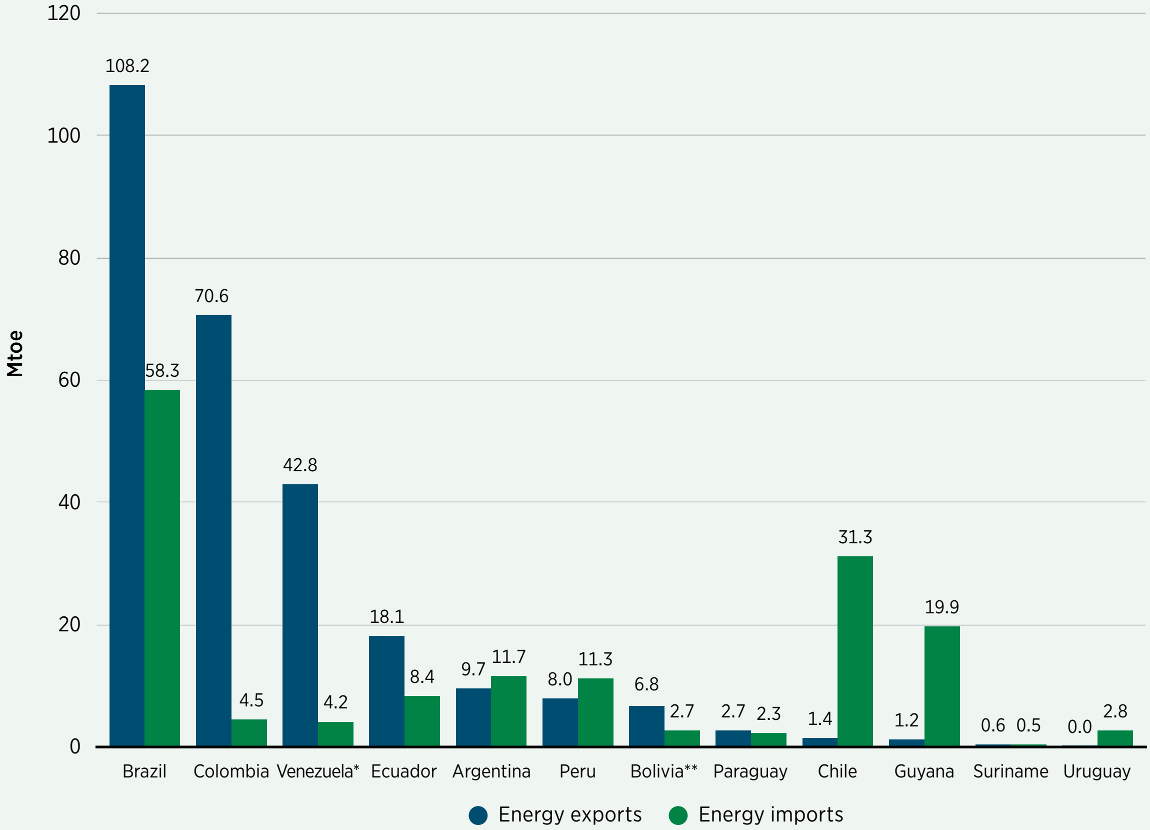



**Source:** (IDB, 2025).

**Note:** * The Plurinational State of Bolivia.

Energy-related trade balances in South America reveal structural contrasts across countries in the region. Crude oil dominates regional exports in the region, with some exceptions: Paraguay exports large amounts of electricity from hydropower plants to Brazil and Argentina through its interconnected power system, while Colombia stands as a major coal exporter in the region. Brazil held the largest energy trade surplus, exporting 108.15 million tonnes of oil equivalent (Mtoe) and importing 58.29 Mtoe, with large contributions from crude oil and biofuels exports. Colombia, the Bolivarian Republic of Venezuela and Ecuador followed with positive net energy trade balances, although with relatively low import levels. By contrast, Chile, Guyana, Uruguay and Peru experienced significant energy trade deficits. Chile exported only 1.43 Mtoe, while importing 31.25 Mtoe; Guyana, despite being an emerging crude oil producer, imported 19.88 Mtoe compared to just 1.23 Mtoe in exports; Uruguay recorded its lowest electricity exports of the past decade in 2023, with an 83% drop compared to the previous year; and Peru became a net energy importer in 2023 following reduced liquefied natural gas production at the Melchorita plant. Argentina also showed a trade deficit in energy, in line with its broader export contraction in 2023, due to a high reliance on electricity imports and limited domestic production of refined oil products, despite its significant crude oil exports (sieLAC and OLADE, 2024) (Figure 8.3). However, persistent deficits in countries like Chile and Guyana, and slowing export momentum in Brazil and Paraguay, signal ongoing structural vulnerabilities in South America's energy trade landscape. Many countries also rely heavily on imports of diesel and other refined oil products due to limited domestic refining capacity; however, this reliance presents opportunities to phase out certain oil products in specific markets without compromising strategic energy exports.

**Figure 8.3** Energy-related exports and imports by country in South America in 2023




**Source:** (sieLAC *et al.*, 2024).

**Notes:** * The Bolivarian Republic of Venezuela; ** The Plurinational State of Bolivia.

Electricity emerges as an opportunity for fostering intra-country trade through integration. South America's electricity matrix has been historically evolved through cross-border projects developed in the 1970s and 1980s. For instance, the Itaipú Dam between Brazil and Paraguay, which now includes a high-voltage direct current transmission line that links Brazil with Argentina and Uruguay, serves as one of the most significant examples of cross-border electricity co-operation. Additionally, other projects include Yaciretá between Argentina and Paraguay, Salto Grande between Argentina and Uruguay, and the Initiative for the Integration of Regional Infrastructure, mainly led by Brazil. The initiative established a Brazil–the Plurinational State of Bolivia–Peru physical corridor, although public opinion concerns were raised in both Peru and the Plurinational State of Bolivia with respect to Brazilian hegemony in the region.

While such integration should have constituted a basis for cross-regional electricity integration for years to come, the region's geography – characterised by long distances and physical barriers between countries – could hamper electricity interconnections. As a results, only 2% of South America's total electricity generation is traded across borders (Agostini *et al.*, 2019).

The diversity of trade balance outcomes across South America, energy or non-energy related, can be traced back to each country's distinct approach to trade openness as well as structural challenges within each economy's landscape. At the same time, the imperative of the energy transition pushes for diversifying partners and solidifying relations with existing ones, especially with major global players.

In this regard, the United States stands out as a long-standing trade partner for many of South America's countries, particularly in the energy sector. This has been marked by a strong legacy of fossil fuel trade, where oil and gas have historically dominated bilateral exchanges, usually with a persistent trade surplus in favour of the United States. According to OLADE, energy trade between the United States and LAC more than doubled in recent years, going from USD 68 billion in 2020 to USD 146.6 billion in 2023.

Thus, the United States makes a strong trading partner for a lot of South American countries. For instance, Brazil and Colombia make up 12% and 8%, respectively, of regional energy flows, second to Mexico, with 43% (OLADE, 2025b). Crude oil makes up a large portion of trade flows between the United States and South American countries. The United States absorbs over half of Argentina's crude oil exports, making it the most dependent on the United States among the listed exporters in the region. Ecuador and Colombia also show significant reliance on United States exports, with shares reaching 45% and 43%, respectively. To a lesser extent, Brazil, Guyana and the Bolivarian Republic of Venezuela also share crude oil-related energy flows with the United States.

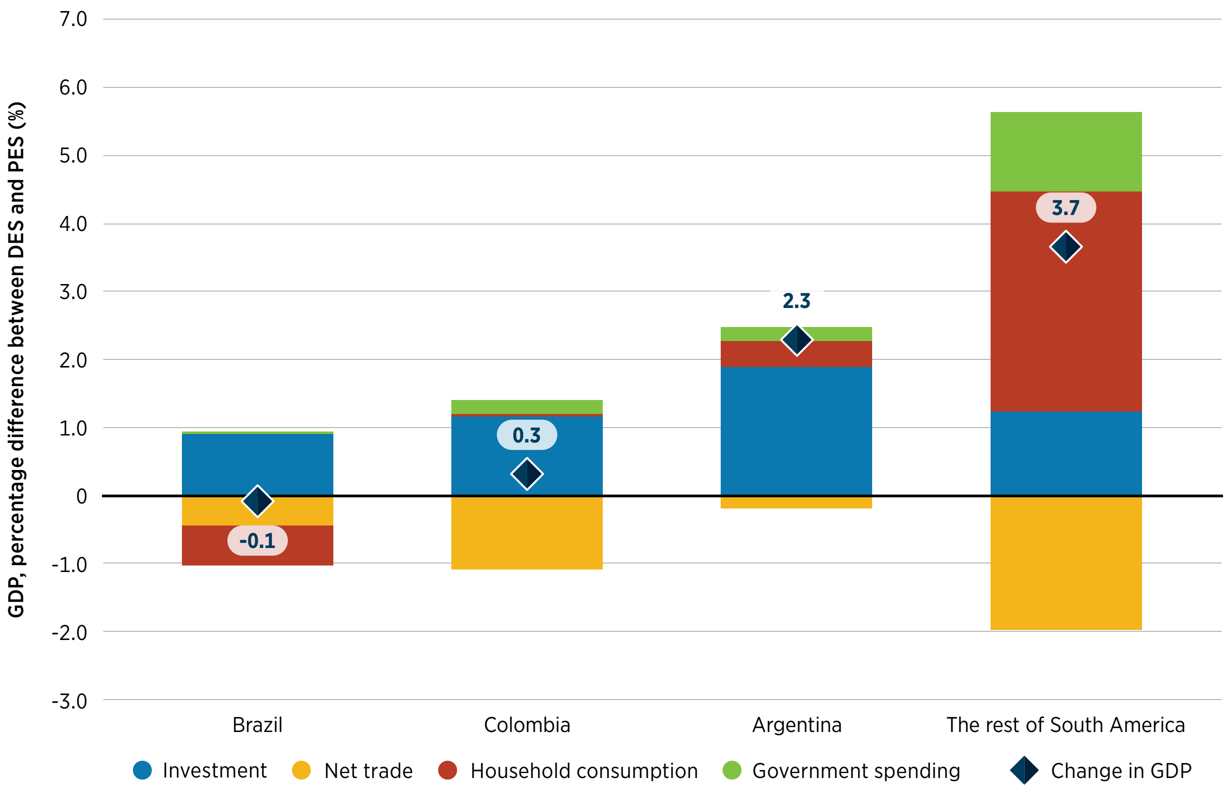
On the other hand, China's expanding presence – through infrastructure investments, technology transfers and development financing – is shifting the balance of power in the region. As a result, this growing influence raises concerns over whether the United States is losing South America to China, especially considering China's ability to provide immediate, large-scale financing.


Although macroeconomic performance in South America is projected to show an overall positive trajectory under the DES, disaggregated results suggest the existence of considerable diversity both in the magnitude and structure of GDP impacts across countries. These, in turn, reflect differences in economic structure and energy system characteristics as well as domestic investment and consumption (Figure 8.4), notably in Brazil, Argentina and Colombia, which together represent around three-quarters of the region's GDP:

- Brazil would see its GDP difference between the DES and PES driven significantly by private investment in transition-related investments, such as in electrification and energy efficiency. The effect is reinforced in the long term, reflecting Brazil's capacity to absorb capital and increase renewable energy deployment, in addition to generating strong induced effects through consumption and domestic supply chains. Increased public investment in grid expansion and flexibility infrastructure also bolsters macroeconomic resilience and job growth, affirming Brazil's role as the region's "locomotive" among transition economies.
- Argentina would see more a gradual but consistent increase in the GDP difference between the two scenarios, with significant public investment in, for example, energy efficiency and renewable infrastructure. A pickup in household consumption supports the upturn, but private investment in the energy transition remains on a slower trajectory. Government spending support for social protection and consumption also helps over the medium to longer term.

- Colombia would experience a negative GDP difference in the first two decades due to the trade driver, turning into a positive GDP difference in the last decade of the transition period, underpinned by strong renewables penetration and household consumption. Although Colombia's economy is vulnerable to decreasing trends in fossil fuel rents, the adverse trade-related effects are offset by vigorous domestic demand dynamics and a shifting energy sector investment structure. Results indicate that Colombia has the potential to achieve a just and economically advantageous transition, although substantively addressing risks associated with fossil phase-down through fiscal reform, regional development and re-skilling programmes will be key.
- For the rest of South America, the GDP difference is overall positive throughout, although this would vary markedly by country depending on its energy mix, fiscal capacity and economic structure. Household consumption is the main engine, increasing over time, behind macroeconomic gains in this subregion, accounting for close to two-thirds of total GDP growth after 2030. This reflects the lagged effects of higher employment, real income growth and lower household energy prices driving increased domestic demand in sectors including retail, services and construction. Induced effects are particularly prevalent in these economies where fiscal redistribution, for example subsidy reform or social investment, amplifies household purchasing power. While investment in clean energy infrastructure also has a positive impact, the size of that driver is lower than in Argentina, Brazil or Colombia. Public investment would play a stabilising role, providing vital infrastructure and enabling the private sector. Trade, like in the rest of the region, is a drag on GDP given the contraction of fossil fuel exports and transitional distortions. Nonetheless, the strong and rising role of domestic consumption underscores the social and economic benefit of the transition, especially when policy is also oriented towards enhancing inclusion and resilience, highlighting the importance and the need for targeted policy interventions and international collaboration.

**Figure 8.4** GDP comparison across South American countries, percentage difference between the DES and PES by driver, 2023-2050

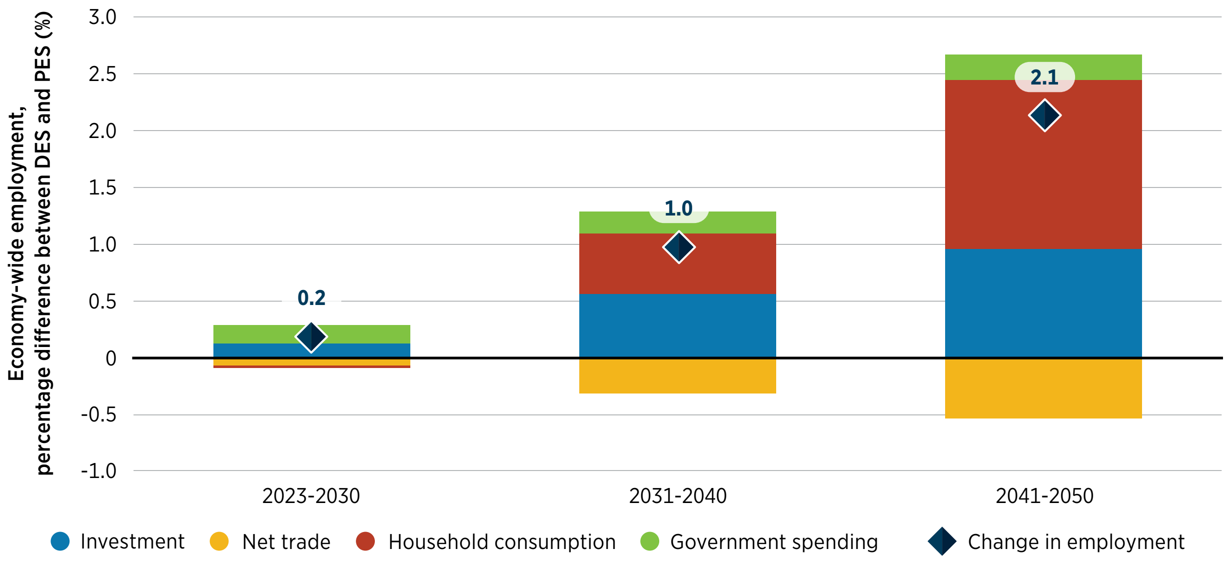


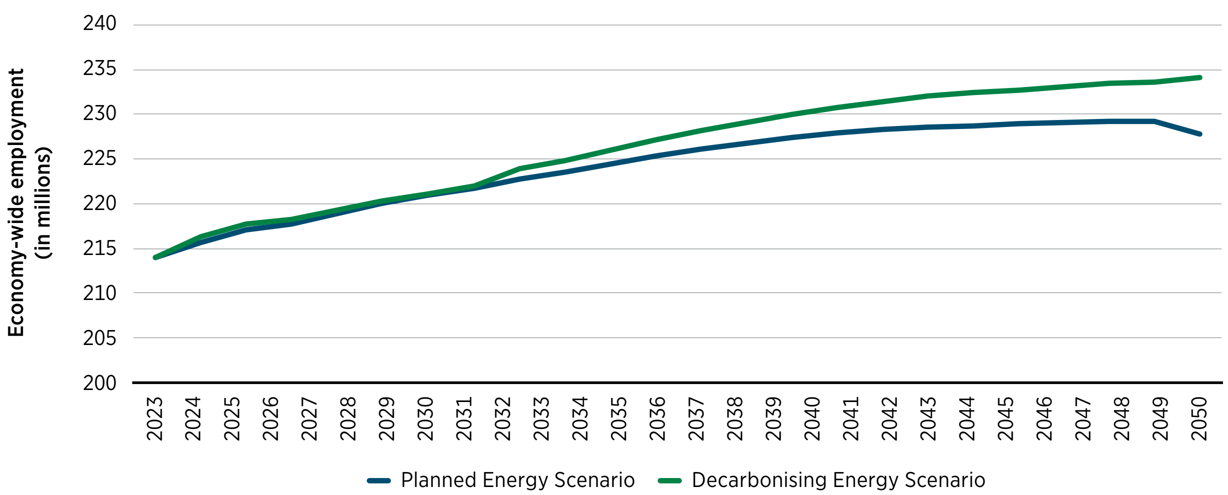
## 8.3 EMPLOYMENT

### 8.3.1 Economy-wide employment

The energy transition in South America is expected to generate an overall net gain in jobs over the PES throughout the transition period. Under the DES, employment exceeds that of the PES by an annual average of 0.2% during the2023-2030 period and 1% in the 2031-2040 period, peaking at 2.1% in the last decade of the transition period and reaching over 6.4 million additional jobs in 2050. This positive impact on employment is primarily shaped by the direct jobs created in clean energy sectors (investment), indirect work along supply chains, and induced effects due to higher income and consumption (household consumption). In contrast, while fossil fuel phaseout does create some labour market frictions, and often heightens inequalities in the short term, these are more than counterbalanced by continued job growth related to renewable energy deployment, energy efficiency, electrification programmes and associated infrastructure investments (Figure 8.5).

**Figure 8.5** South America economy-wide employment, percentage difference between the DES and PES (top) and absolute number in the DES and PES (bottom)



Under the DES, gains in economy-wide employment are driven by reinforcing dynamics across investment, fiscal policy and household-driven demand. Although the total effect on employment difference is positive over the transition (with an annual average of around 1.2% throughout the transition period), the distribution of factors influencing the difference shifts over time. The early phase (*i.e.* 2023-2030) sees small employment gains (annual average of 0.2% above the PES), facilitated largely by **investment** and **government spending** in clean energy infrastructure, energy efficiency and electrification. The impact of the fossil fuel supply investment and extraction activities is notably negative given the region's level of fossil fuel extraction and employment intensities. The effect is strongly negative after 2030, when the fossil fuel phaseout accelerates. By 2050, there are over 702 400 jobs due mainly to declines in fuel extraction activities, which would require policy intervention to retrain workers for other jobs and avoid major disruptions to living standards. These occupations are typically concentrated in specific regions (with around 0.7% 10.9% of the job losses located in Colombia, 23.6% in Brazil and around 64.8% in the rest of South America) and have a regional impact, emphasising the need to consider the diverse geographic effects to develop focused policy interventions. Nevertheless, throughout the transition period (*i.e.* 2023-2050), the overall number of jobs created in transition-related sectors (especially in renewables, energy efficiency and electrification) is expected to be higher than the number of job losses in the fossil fuel sector.

Contrary to changes in GDP, **household consumption** effects on employment difference between the DES and PES start to play a more important role from the second decade (*i.e.* 2031-2040) of the transition period, alongside continued investment substantially boosting demand through to 2050. This trend reflects the spillover effects from frontloading investment in sectors related to the power sector (*e.g.* electricity supply, construction, distribution and retail, business services), which boost household incomes through increased labour demand and wage growth, in turn stimulating greater consumer spending and further reinforcing job creation across sectors like basic manufacturing and public and personal services.

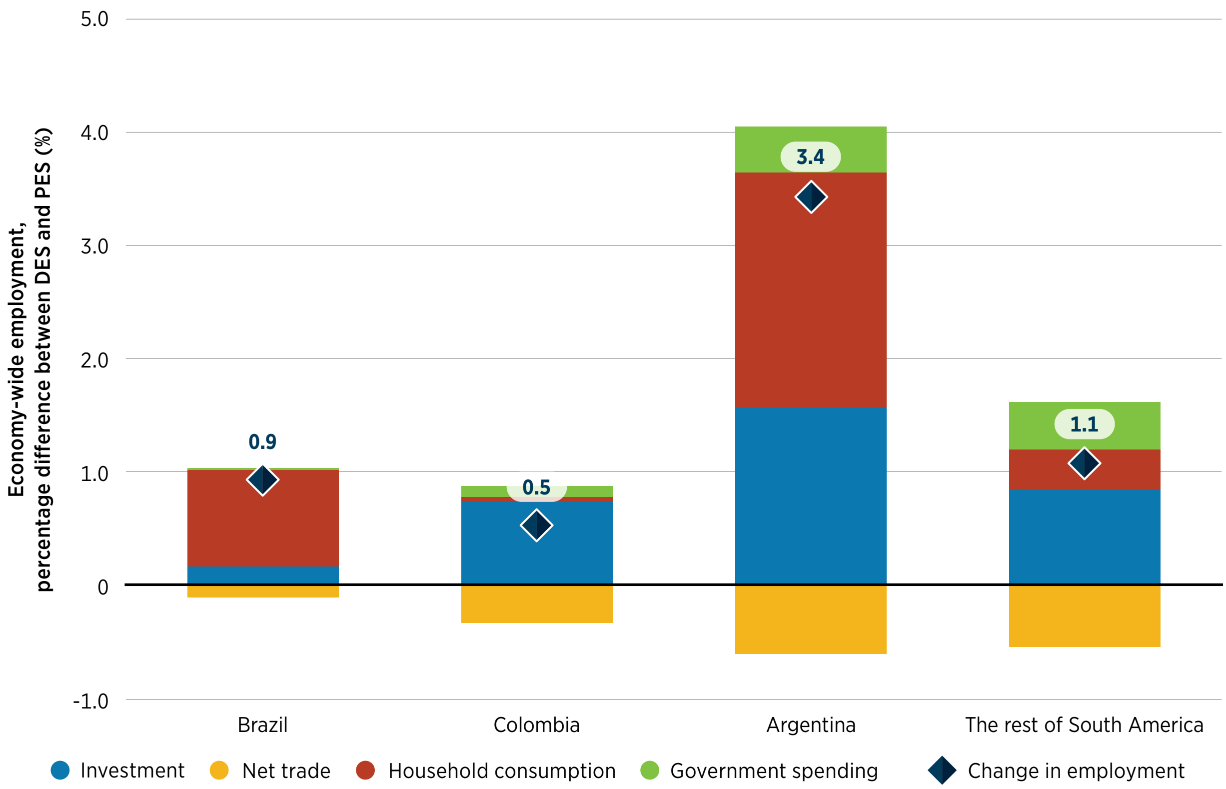
The gap becomes much more significant by 2041-2050, at an annual average of 2.1% above the PES, with household consumption as the main source of labour market growth. Induced impacts, via higher disposable income, enhanced access to modern energy and fiscal redistribution, become the main driver of employment creation. Though **net trade** drags down employment in all periods, its impact is outweighed by domestic demand-side dynamics and the crucial role played by a just transition.

Regional perspectives indicate a steady improvement in net employment under the DES, but the aggregate figures can hide subregional differences reflecting variations and diversity in the scale, composition of drivers and timing of gains. Under the DES, **Argentina** makes the largest gains in employment, with an annual average increase of 3.4% over the PES, but only equivalent to around 31% of the region's absolute employment gains in 2050 (*i.e.* around 2 million additional jobs), driven by an adequate balance of ripple effects from transition-related investment (particularly in renewables, energy efficiency and electrification) and consumer spending (Figure 8.6). On the other hand, **Brazil** would record an annual average increase of 0.9% in employment throughout the transition period over the PES, but would represent the highest absolute employment gain, *i.e.* around 41% of the region's employment gains in 2050 (equivalent to around 2.7 million additional jobs). This trend would be mainly driven by household consumption, which would contribute with strong income-induced effects resulting from the investment stimulus observed under the GDP driver analysis.

Consumption would move from fuels to restaurants, hotels and other goods and services, such as education, personal costs and financial services. **Colombia**, with an even weaker annual average increase of 0.5% (equivalent to around 635 000 additional jobs or 10% of the region's absolute employment gains), would be mainly supported by investment, alongside a more resilient negative drag from its net trade performance. More investments allocated to service-oriented sectors, such as building space redesign, energy management system upgrades and retrofits, would outweigh job losses in certain sectors, including fuel extraction activities and the manufactured fuels sectors.

The **rest of South America** would see an annual average 1.1% increase in employment, driven positively by investment, followed by household consumption and government spending, and negatively by the net trade driver. While fossil fuel-exporting economies in this group experience a net trade-related employment loss, these are outweighed by induced effects and growth in clean energy services. The results highlight the importance of labour market planning on a country-by-country basis and the need to have social policies in place that leverage local strengths while minimising transition risks.

**Figure 8.6** Economy-wide employment comparison across South American countries, percentage difference between the DES and PES by driver, 2023-2050




## 8.3.2 Energy-sector jobs

Transitioning from fossil fuels to alternative low-carbon energy and power sources will involve declines or shifts in these and related industries, requiring careful management of job transitions. The most urgent transition in this respect is coal, which is a major employer and has legacy impacts in mining regions in Colombia. Colombia's road map confirms that the transition will be knowledge-intensive and be based on reskilling and training to prepare and educate the country and professionals. The Colombian government's programme to support the production of hydrogen and critical minerals prioritises working with Indigenous groups for investment in large-scale solar and wind developments and ensures that benefits accrue to local communities to improve livelihoods and jobs.

Decarbonisation initiatives create new markets and opportunities to address the gender gap and informal jobs in the region. While this is an opportunity for the emergence of new job programmes that are tailored to these issues, this could also be enabled simply by expanding current programmes. For example, the Plurinational State of Bolivia's Program for the Support of Employment provides jobseekers incentives to attain formal employment experience. The programme has shown overall positive results that turn out to be more pronounced for women than men (Novella & and Valencia, 2022).

Across the region, countries are setting ambitious targets to generate employment from sustainable energy transitions. Chile aims to create 100 000 new direct and indirect energy jobs by 2030 through its energy strategy for the mining and industry sectors. The growing hydrogen industry also holds significant job potential: estimates suggest that by 2050, it could generate up to 94 000 jobs in Peru, 180 000 in Brazil and over 30 000 in Uruguay. As low-carbon sectors expand, the energy transition can serve as a catalyst for more inclusive, formal and resilient labour markets in South America.

In South America, total jobs in the energy sector are projected to increase substantially throughout the transition period, from 5.8 million jobs in 2023 to 7.6 million under the PES by 2050 and to 12.4 million jobs under the DES by 2050 (Figure 8.7). This growth is mainly driven by strong renewable, energy efficiency and power grid/flexibility job growth offsetting falling conventional energy sectors (*i.e.* fossil and nuclear energy). Jobs in the fossil and nuclear sectors would decline from around 3.1 million in 2023 to around 2.7 million under the PES by 2050 and 0.9 million under the DES by 2050.

Energy conservation and efficiency becomes the biggest jobs category in the energy sector by employment under the DES, increasing from about 0.2 million jobs in 2023 to 4.6 million by 2050, driven largely by investments in building retrofits, industrial compliance, efficient appliances, *etc*. Renewable energy jobs would expand from about 1.7 million in 2023 to 3.1 million in 2050 with accelerated deployment of solar and wind. Power grids and flexibility sector jobs would increase from 0.7 million to 3.7 million. This evolution is mainly due to grid modernisation and expansion, and higher integration of the variable renewable energies (VREs). Together, the transition-related sectors (*i.e.* renewables, energy conservation and efficiency, and power grids and flexibility) represent over 90% of all energy sector jobs in the region by 2050 under the DES, emphasising their central importance in driving sustainable and inclusive employment growth.

**Figure 8.7** Energy sector jobs in South America under the PES and DES, by sector, 2023-2050

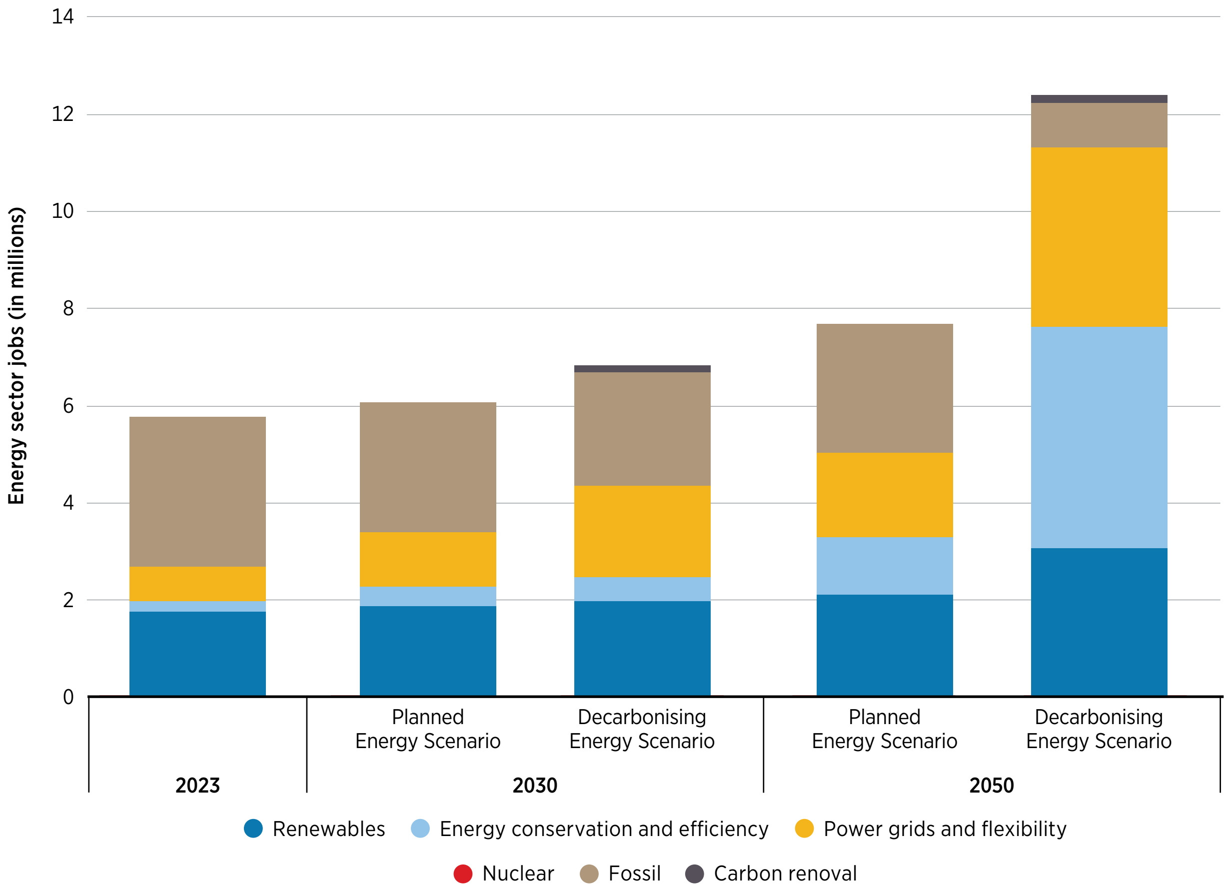
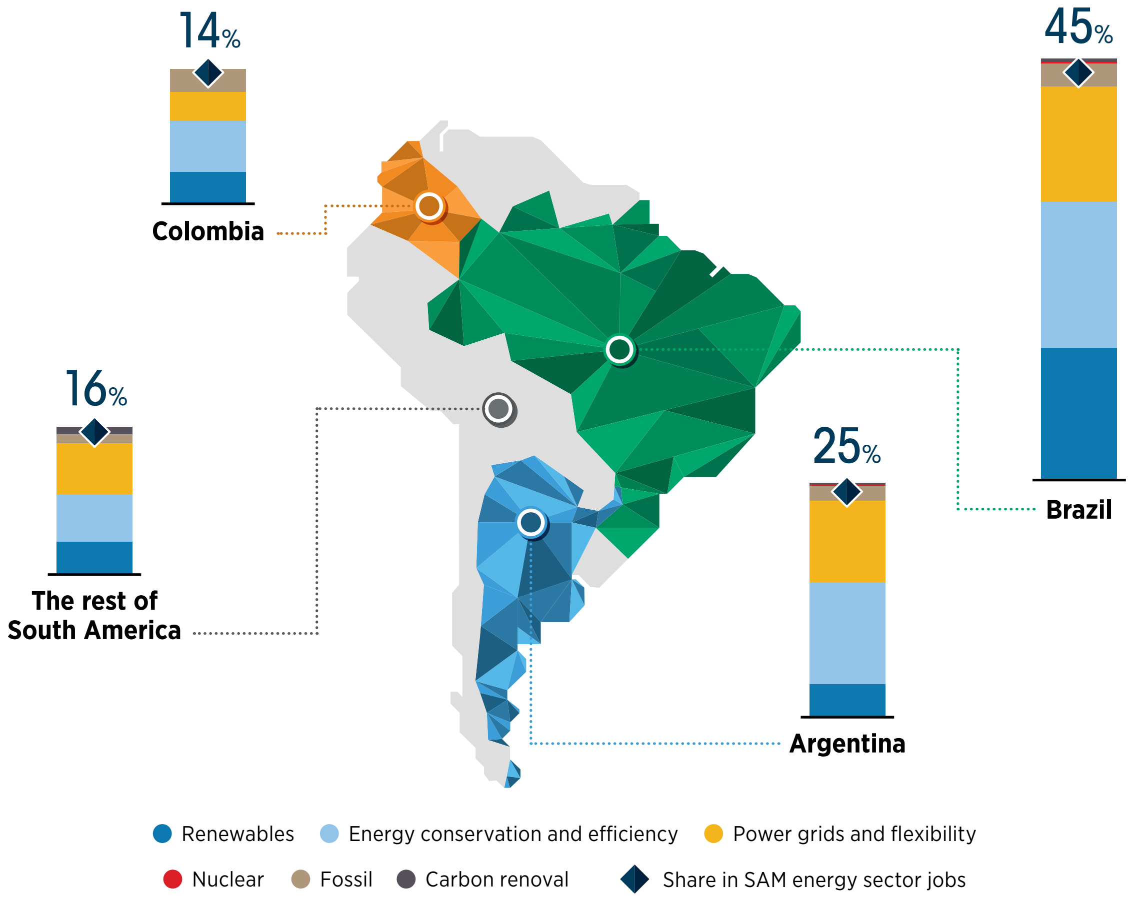


Figure 8.8 shows the regional breakdown of energy sector jobs in 2050 under the DES. In 2050, Brazil accounts for 45% of the region's total, driven primarily by growth in renewables, energy conservation and efficiency, and power grids and flexibility, totalling 5.2 million jobs. Argentina follows with 25%, largely from energy conservation and power grids and flexibility, reaching 2.4 million jobs, while its renewables share remains modest at 0.4 million compared to Brazil's 1.8 million. Colombia contributes 14%, mainly from energy conservation and efficiency, while the rest of South America's countries collectively account for just 16% of regional energy sector jobs.

**Figure 8.8** Breakdown of energy sector jobs across South American countries under the DES, by sector, 2050



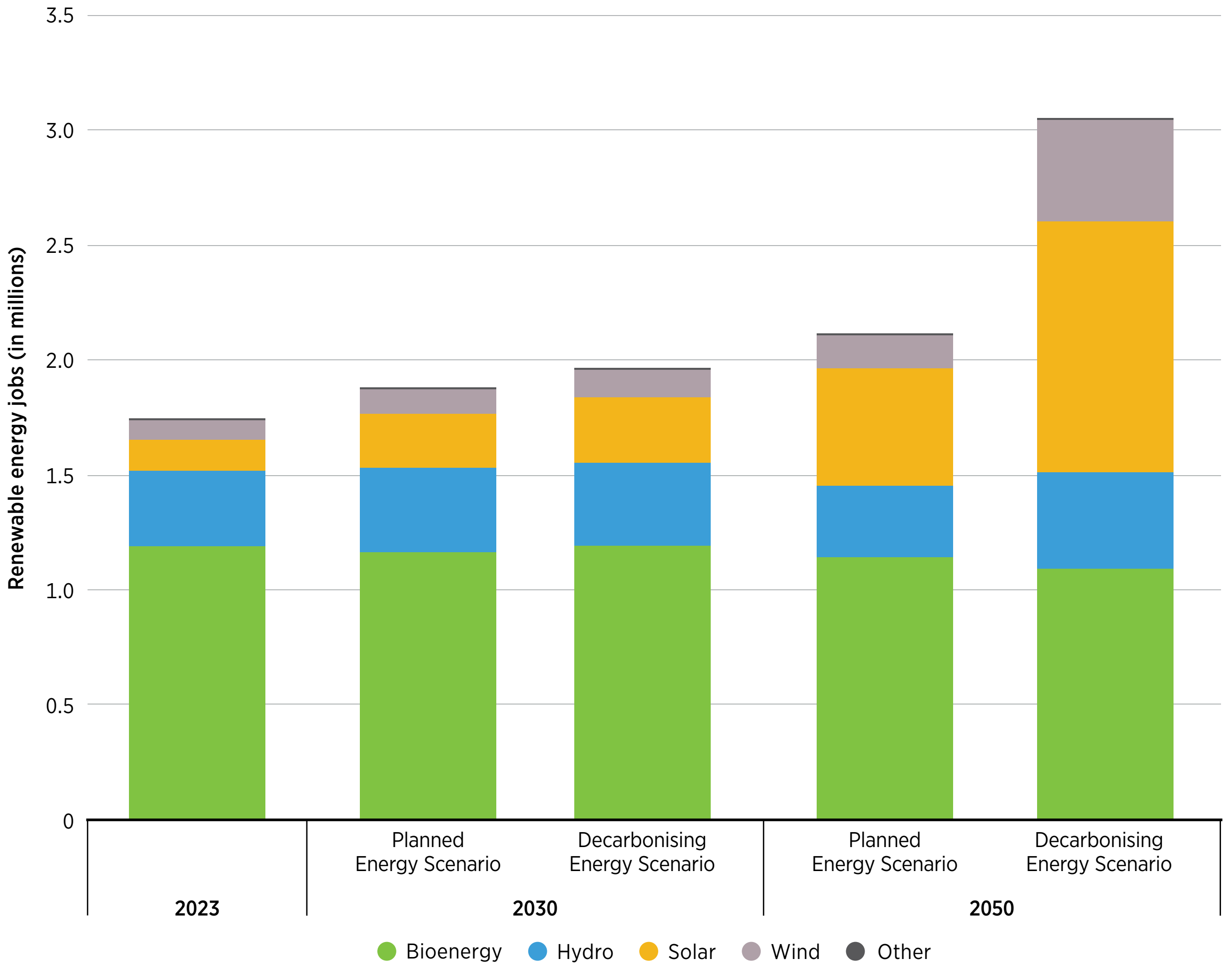

**Note:** SAM = South America.

Disparities in regional employment figures across South America could stem from multiple interconnected drivers. Brazil's dominance reflects its abundant renewable energy potential, large domestic market and the scale of its net-zero transformation, which represents a USD 6 trillion opportunity through 2050 (BNEF, 2025d). These advantages attract significant investment and skilled labour, in contrast to smaller economies or those with limited infrastructure and weaker policy incentives, which face slower clean energy job growth. Beyond Brazil, South America's wealth of critical minerals and other transition-related resources could offer significant potential for job creation and industrial upgrading. However, differences in resource endowments, the existing energy systems and countries' regional influence would shape how these opportunities would be mobilised, thus setting the pace and scale of local value creation and the impacts on employment across the region.

### 8.3.3 Renewables jobs

Renewable energy employment is projected to increase steadily in South America, from around 1.7 million jobs in 2023 to 1.9 million in 2030 and to 2.1 million in 2050 under the PES. However, in the DES these jobs would increase even more substantially, reaching nearly 2 million jobs in 2030 and 3.1 million in 2050 (Figure 8.9). In all scenarios, bioenergy is expected to remain the primary source of jobs in the renewable energy sector throughout the transition period (*i.e.* 2023-2050), with ample biomass resources and an extensive supply chain support system in place throughout the region. Bioenergy jobs would reach more than 1 million by 2050, equivalent to around 36% of total renewable jobs. The solar sector would experience the largest employment growth over the same period, increasing by more than eightfold to reach more than 1 million jobs by 2050 (*i.e.* representing more than one-third of total renewables jobs). Wind employment would also increase modestly (representing over 14% of total renewables employment in the region by 2050, which is over 435 000 jobs), supported by continued deployment of onshore wind and growing offshore investments in a few countries, such as Brazil and Argentina. Employment in hydropower would remain stable, reflecting the operation of existing plants and a few new investments throughout the last decade of the transition period (*i.e.* 2041-2050), contributing to around 14% of renewable jobs by 2050 (*i.e.* around 420 000 jobs) under the DES.

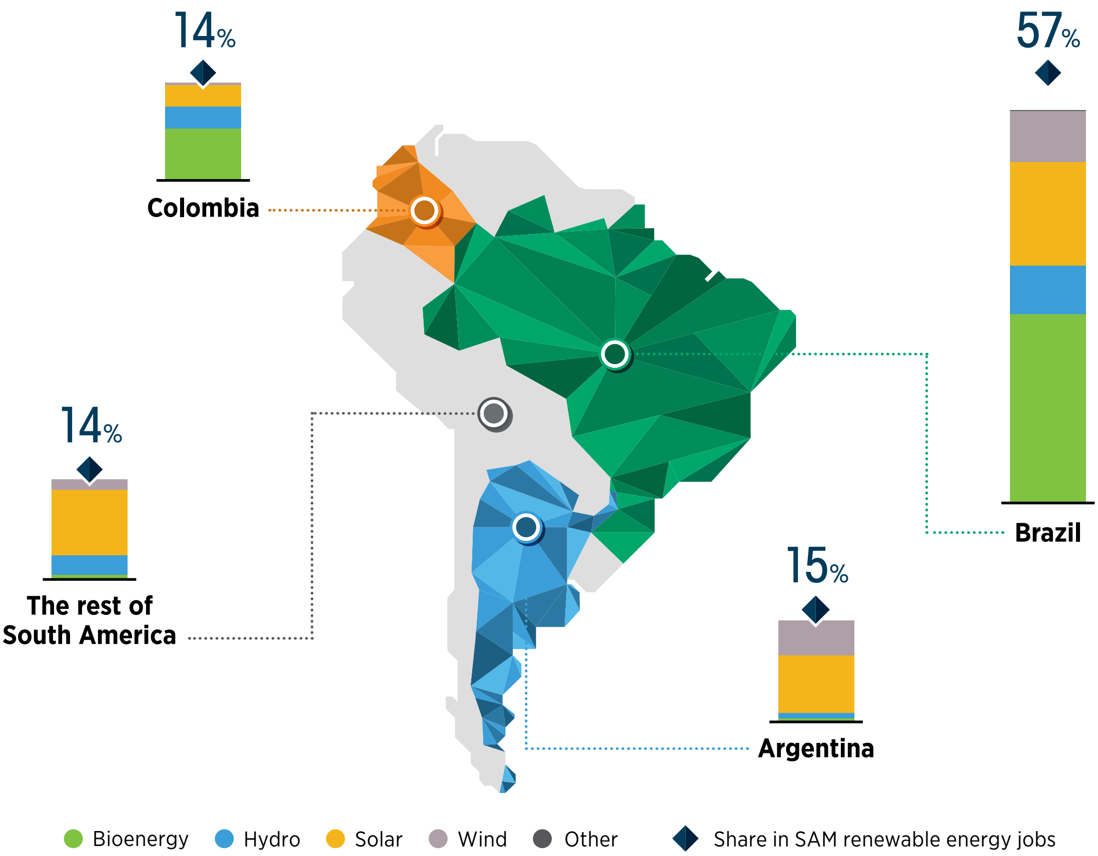
**Figure 8.9** Renewable energy jobs in South America under the PES and DES, by technology, 2023-2050




**Note:** "Other" includes geothermal and tidal/wave.

Figure 8.10 shows the regional and technological distribution of renewable jobs through 2050 under the DES. Brazil would lead with 57% of the total, driven primarily by bioenergy, which would account for 831 000 jobs, and solar technologies with 458 000 jobs, while wind and hydropower would generate 227 000 and 212 000 jobs, respectively, in 2050 under the DES. Argentina would follow with 15%, led by solar technologies at 255 000 jobs and wind at 153 000 jobs. Colombia would account for 14% of total regional renewable jobs, mainly from bioenergy, with 227 000 jobs, while hydropower and wind would each account for 96 000 jobs created. The rest of South America's countries would share the remaining 14% of total renewable energy jobs in the region, largely driven by solar technologies generating 285 000 jobs, hydropower with 89 000 jobs and wind with 45 000 jobs.

**Figure 8.10** Renewable energy jobs across South American countries under the DES, by technology, 2050

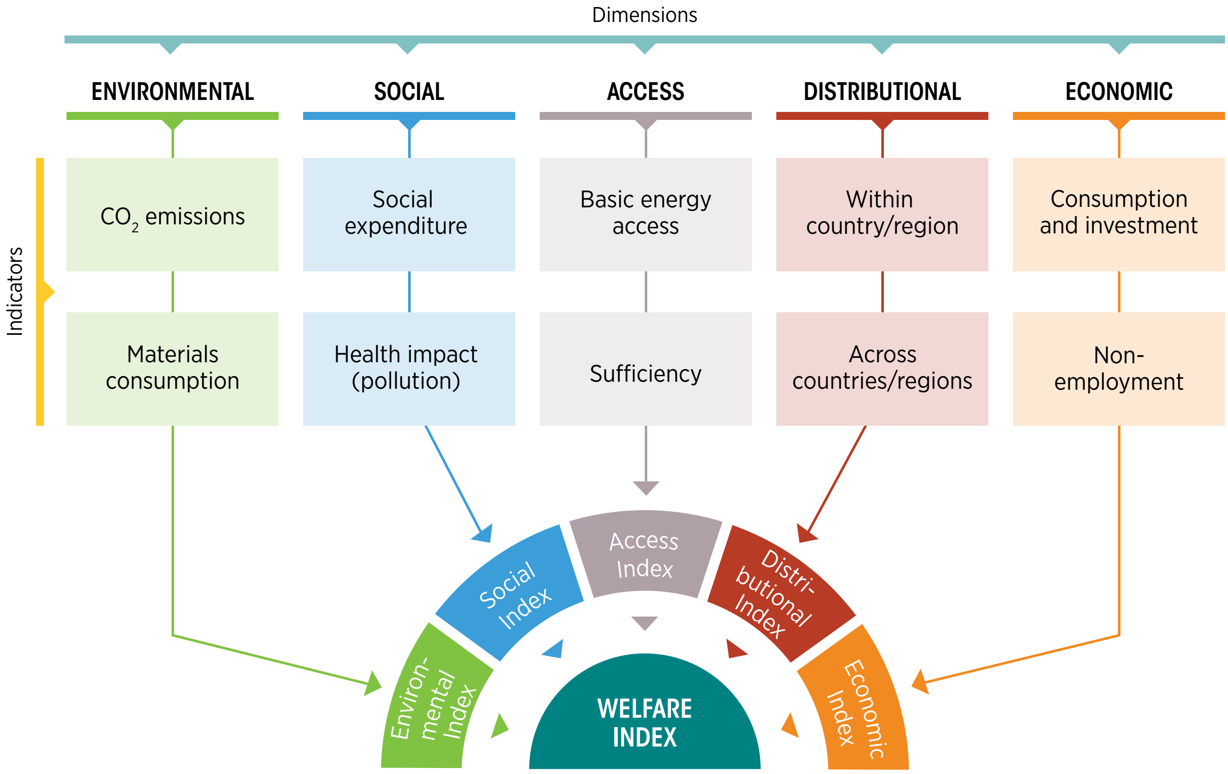



**Notes:** "Other" includes geothermal and tidal/wave; SAM = South America.

## 8.4 THE ENERGY TRANSITION WELFARE INDEX

GDP is the indicator still used as the standard measure of economic output, but GDP does not account for many other things that society considers important, such as human health, fulfilling jobs and environmental quality. And while climate change will likely have negative impacts on future GDP, it also will have significant impacts on societies, nature and economies that no measure of GDP captures. Therefore, relying solely on GDP can be incomplete and potentially misleading. To better reflect social well-being in the context of the energy transition, IRENA's Energy Transition Welfare Index (IRENA, 2016, 2019b, 2019c, 2020, 2021b, 2022e, 2023d, 2024a) has been developed and refined for an extended impact analysis. The Welfare Index provides a comprehensive framework to assess the impacts of this transition through five dimensions: economic,[49] social,[50] environmental,[51] distributional[52] and access.[53] Each dimension incorporates two indicators (Figure 8.11).

**Figure 8.11** Structure of IRENA's Energy Transition Welfare Index




**Source:** (IRENA, 2021b)

**Note:** $CO_2$ = carbon dioxide.

[49] *The economic dimension is composed of 1) per capita consumption and investment; and 2) the non-employment rate, which is the share of the working age population that is neither employed nor in education.*

[50] *The social dimension is composed of 1) social expenditure expressed as per capita public expenditure; and 2) the health impacts of pollution expressed as per capita health damages due to energy-related air pollution.*

[51] *The environmental dimension consists of two indicators: 1) cumulative $CO_2$ emissions; and 2) per capita materials consumption formulated in terms of domestic materials consumption, which includes metals, non-metallic minerals and biomass (wood, food) but excludes fossil fuels.*

[52] *The distributional dimension measures income and wealth inequality within and across countries.*

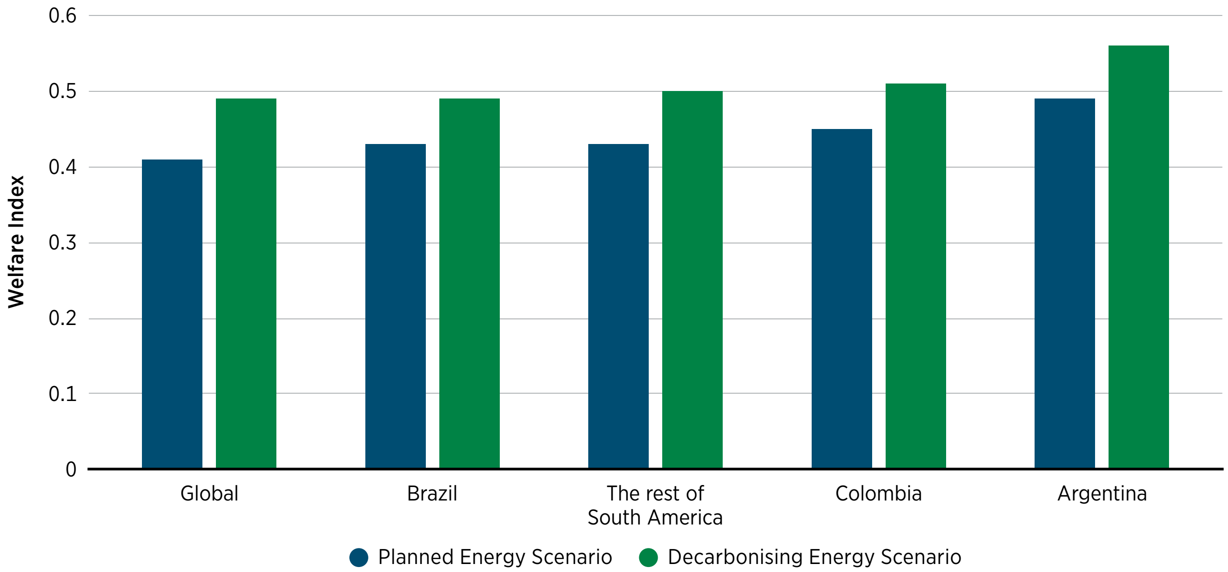
[53] *The access dimension is informed by 1) the access rate to basic energy; and 2) the progression along the energy sufficiency level (assumed at 20 kWh/capita/day) in line with the literature (Millward-Hopkins et al., 2020).*

To maximise human welfare benefits, a decarbonised energy system must be managed through holistic policies that deliver sustained economic and environmental dividends equitably. In addition, an inclusive approach to provide broader access should be supportive of development and compatible with the goals.

The methodological framework of the Energy Transition Welfare Index uses an approach tailored to allow a direct comparison between scenarios and illustrates how targeted policies can improve socio-economic outcomes, while identifying potential challenges for policy makers. This framework defines ten indicators, divided into five dimensions that cover economic, social, environmental, distributional and access (Figure 8.13) (IRENA, 2021b). In essence, once indicators are normalised, they are aggregated through an equally weighted geometric mean to generate the dimension indices, and in turn aggregated to the overall Welfare Index using the logarithmic shares. A similar methodological framework is also currently used by other international and multilateral organisations for their respective indices, such as the United Nations Industrial Development Organization's Competitive Industrial Performance and the African Development Bank's Africa Industrialisation Index. These indices measure industrial performance and competitiveness based on a set of 8 and 19 indicators, respectively (AfDB *et al.*, 2022; UNIDO, 2013).

The Energy Transition Welfare Index and its five dimensions are structured on a scale ranging from 0 (low performance) to 1 (high performance). Figure 8.12 presents the average Welfare Index values for the PES and the DES in selected countries and regions throughout the 2024-2050 period. The highest-performing cases are, at most, around 0.5, signalling that substantial socio-economic goals have not been met and plenty of room for improvement remains.

**Figure 8.12** The Energy Transition Welfare Index under the PES and DES in the region, 2023-2050

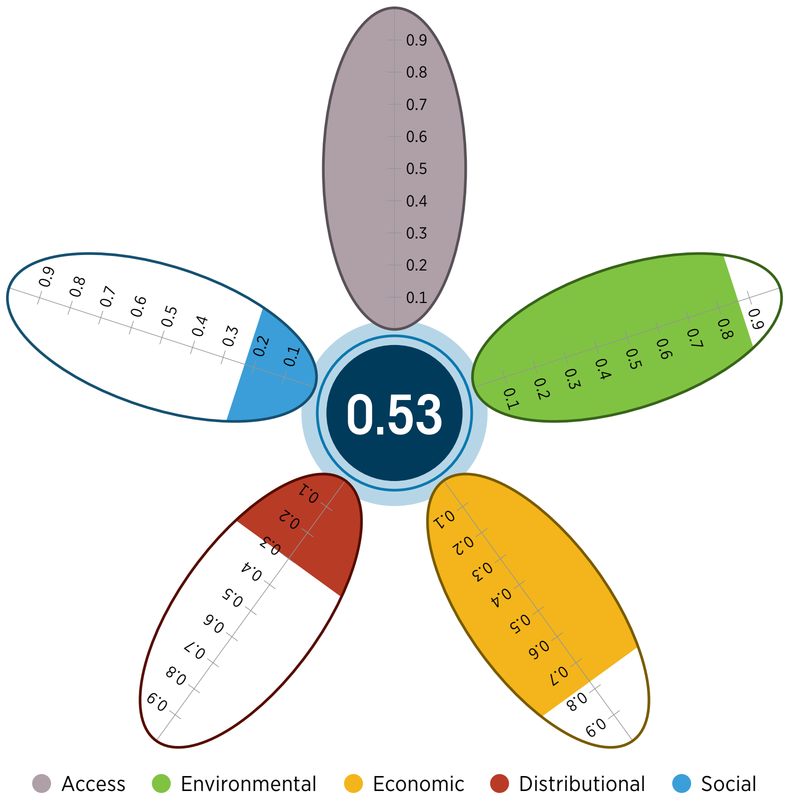



**Note:** The Welfare Index is on a scale from 0 (low performance) to 1 (high performance) and represents the absolute value of the overall Welfare Index.

The DES, with its mitigation impacts and supportive policies, generates far greater welfare improvements than does the PES in all regions (Figure 8.12). Under the DES, all four South American subregions (Brazil, Argentina, Colombia and the rest of South America) reach levels of welfare higher than the global average throughout the transition period. Argentina records the highest welfare improvements in South America with a score of 0.56, followed closely by Colombia at 0.51 and the rest of South America at 0.50. Brazil's welfare improvement score is 0.49.

While the Energy Transition Welfare Index allows for clear comparisons between scenarios and regions, the index value can neither explain the underlying drivers behind the results nor pinpoint specific policy instruments responsible for particular improvements. Indices for each of the five dimensions are therefore presented separately to shed light on the driving factors. The overall Welfare Index and its five dimensions for South America in 2050 under the DES are shown in Figure 8.13.

**Figure 8.13** Overall Energy Transition Welfare Index and its dimensional indices under the DES by 2050 in South America




**Note:** The five petals are on a scale from 0 (low performance) to 1 (high performance) and represent the absolute values of the five dimensions of the Welfare Index. The number in the centre is also on a scale from 0 to 1 and represents the absolute value of the overall Welfare Index.

Figure 8.13 also suggests that there is significant room for improvement in the social and distributional dimensions in the South America region, with additional, albeit more modest, potential in the economic and environmental dimensions due to their very low material consumption. This holds true despite the DES incorporating supportive policies to progress overall welfare, especially social and distributional dimensions. To make more progress would entail making fundamental changes that overhaul socio-economic systems and redirect economic activity away from the pursuit of wealth and toward creating shared prosperity.

## 8.5 INDUSTRIAL AND CIRCULAR ECONOMY POLICIES

Industrial policies have increasingly been proposed in South America as a means of promoting renewables deployment and for incentivising new markets such as hydrogen, biofuels and critical minerals.

In Argentina, the proposed Bill on the Promotion of Domestic Production of Electric and Hybrid Vehicles stipulates the framework for the industrialisation of lithium and the production of batteries in the country, providing educational and skills training programmes for those interested in working in the industry. Brazil's New Industry Brazil strategy, approved in December 2024, sets ambitious decarbonisation and energy transition targets backed by BRL 300 billion (USD 55.7 billion) in investment through 2026. This strategy includes expanding the use of biofuels, EVs, green hydrogen, SAF and biomethane, as well as the local production of wind and solar technologies.

The New Industry Brazil policy aims to raise the share of clean fuels in transport energy use to 27% by 2026 and 50% by 2033, and to boost the sustainable use of biodiversity by 30% by 2033 (Government of Brazil, 2024b). Although Brazil's push for "neo-industrialisation" is largely framed as economic development, its implementation will depend on a significant increase in renewable energy supply.

In Colombia, industrial policy is embedded in the broader energy transition agenda through a pillar on Productive Transformation and Climate Action, prioritising non-mining exports, technology investment, renewable energy, sustainable transport and deforestation reduction. The country's reindustrialisation strategy focuses on shifting from an extraction-based to a knowledge-based, sustainable economy.

Local content requirements are seen as a tool to leverage industrial development and job creation during the energy transition. These support domestic manufacturing and skills development, particularly in low- and medium-skilled segments of the renewable energy value chain. While Brazil has developed a successful wind industry supported by its national development bank's local content requirement policies, its solar PV market remains heavily dependent on imports. Globally, across the solar PV supply chain (*i.e.* polysilicon, ingots, wafers, cells and modules) in September 2024, Chinese manufacturers' share exceeded 80% and was sometimes close to 100% (Zissler, 2024). Brazil now enforces local content policies for wind, solar, BESS and hydrogen projects, but sustaining domestic supply chains will require stable demand and market expansion – such as offshore wind – to avoid collapse.

At the same time, the shift toward a circular economy is expected to bring net gains in employment and GDP across the region, while also contributing to emissions reductions. GDP could increase, ranging from 0.82% in Chile to 2.4% in Peru, alongside job creation of up to 1.9% (OECD, 2022b). Countries have begun adopting national circular economy strategies, such as Chile's 2040 road map, Colombia's national strategy (2019) and Peru's industrial circular road map, which help define responsibilities, co-ordinate public-private efforts, and guide innovation across sectors through government, academia and private sector collaboration.

To ensure these industrial and circular economy transitions are just and inclusive, strong institutional co-ordination will be essential. Governments must align structural reforms, investment strategies and social policies to avoid leaving communities behind. A holistic policy approach, supported by global co-operation, financing and technology sharing will be crucial for South America to not only meet its decarbonisation goals but also generate long-term economic and social benefits from its low-carbon industrial transformation

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