



Regional energy transition outlook

SOUTH AMERICA

EXECUTIVE SUMMARY

© IRENA 2025

Unless otherwise stated, material in this publication may be freely used, shared, copied, reproduced, printed and/or stored, provided that appropriate acknowledgement is given of IRENA as the source and copyright holder. Material in this publication that is attributed to third parties may be subject to separate terms of use and restrictions, and appropriate permissions from these third parties may need to be secured before any use of such material.

ISBN: 978-92-9260-658-9

Citation: IRENA (2025), *Regional energy transition outlook: South America*, International Renewable Energy Agency, Abu Dhabi.

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

Acknowledgements

The report was led by Ricardo Gorini, under the guidance of Norela Constantinescu and Ute Collier.

The lead authors were: Krisly Guerra, Seán Collins, Hannah Sofia Guinto, Diala Hawila, Bishal Parajuli and Gondia Sokhna Seck (IRENA); Juliana Marreco, Pablo Rimancus and Sabina Tribenti (consultants).

Substantive contributions and analysis were provided by: Assiya Hasni, Rodrigo Leme, Milenko Matosic Suárez, and Yuan Sun (IRENA); Melda Jabbour, Stuti Piya and María Vicente García (consultants).

The authors wish to thank the Inter-American Development Bank (IDB) for its support in facilitating the power sector modelling of the region in PLEXOS, Juan Roberto Paredes (IDB) for the assistance in engagement activities and report review, and Frank Leañez (consultant) for the South American countries' analysis.

Internal review, inputs and contributions were provided by: Francisco Gafaro, Paul Komor, Larissa Pupo Nogueira, Erick Ruiz Araya, Danial Saleem and James Walker (IRENA); Chun Sheng Goh (ex-IRENA). Engagement support, inputs and report review were provided by José Torón and Camilo Ramírez Isaza (CEP).

Crucial for the RETO South America was the high level of engagement with the countries of the region, their national representatives and technical staff of institutions and associations, who provided feedback and external review at different stages of the project.

IRENA also appreciates the contributions, support and participation in workshops of the regional organisms OLADE and ECLAC, and regional blocks SIESUR and SINEA.

Editorial co-ordination and production were provided by Francis Field and Stephanie Clarke. Administrative support was provided by Ling Ling Federhen. The report was edited by Jonathan Gorvett and Stefanie Durbin, with design by Nacho Sanz.

IRENA is grateful for the funding support of the European Commission for this report.

For further information or to provide feedback: publications@irena.org

This report is available for download: www.irena.org/publications

Disclaimer

This publication and the material herein are provided "as is". All reasonable precautions have been taken by IRENA to verify the reliability of the material in this publication. However, neither IRENA nor any of its officials, agents, data or other third-party content providers provides a warranty of any kind, either expressed or implied, and they accept no responsibility or liability for any consequence of use of the publication or material herein.

The information contained herein does not necessarily represent the views of all Members of IRENA. The mention of specific companies or certain projects or products does not imply that they are endorsed or recommended by IRENA in preference to others of a similar nature that are not mentioned. The designations employed and the presentation of material herein do not imply the expression of any opinion on the part of IRENA concerning the legal status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.



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, investment would be 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 regional 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.

As an example, 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 now is 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 (CO₂) 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, 2030, 2040 and 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 ₂ eq) ^[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 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 jobs (in million) | 3.1 | 2.7 | 2.9 | 2.7 | 2.4 | 1.3 | 0.9 |
| Share of clean cooking technologies into residential stock (%) ^[9] | 7% | 5.6% | 9% | 12% | 6.3% | 47% | 87% |

TOTAL SYSTEM COSTS^[10]

| | | | | | | | |
|-----------------------------------------------------|---|-----|-----|-----|-----|-----|-----|
| Cumulative - investment (trillion USD - 2024 base) | - | 0.5 | 1.2 | 1.7 | 0.8 | 2.5 | 4.2 |
| Cumulative - expenditure (trillion USD - 2024 base) | - | 0.7 | 1.5 | 1.9 | 0.7 | 1.9 | 2.8 |
| Cumulative - fuel costs (trillion USD - 2024 base) | - | 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; CO₂ = carbon dioxide; EJ = exajoule; GW = gigawatt; H₂ = 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 scenario, 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 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 | <ul style="list-style-type: none"> • 153 million vehicles (vs. 128 million units in 2023) • 5% share BEVs of the total fleet (vs. 0.2% in 2023) • 28% share flex-fuel vehicles of the total fleet • 1.2 million charging points (vs. 0.1 million points in 2023) • Electricity share: 1% in sector's TFEC (vs. 0.2% in 2023) • Biofuels share: 18% in sector's TFEC (vs. 13% in 2023) ✓ Introduction of clean hydrogen into cargo transportation ✓ Blending ratios (volume) of biodiesel in the range of 10% - 20% and bioethanol range 10% - 30% | <ul style="list-style-type: none"> • >200 million vehicles • >40% share BEVs of the total fleet • 23% share flex-fuel vehicles of the total fleet • 22 million charging points • Electricity share: 15% in sector's TFEC • Biofuels share: >25% in sector's TFEC • Clean hydrogen share: <1% in sector's TFEC ✓ Blending ratios (volume) of biodiesel in the range of 15% - 25%, bioethanol range 15% - 30% and SAF up to 40% | <ul style="list-style-type: none"> • 254 million vehicles • >75% share BEVs of the total fleet • 19% share flex-fuel vehicles of the total fleet • 55 million charging points • Electricity share: 45% in sector's TFEC • Biofuels share: 35% in sector's TFEC • Clean hydrogen share: <1% in sector's TFEC ✓ 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 | <ul style="list-style-type: none"> • Sector energy intensity of 15 MJ/USD (vs. -16 MJ/USD in 2023) • Electricity share: 24% in sector's TFEC (vs. 19% in 2023) • Bioenergy share: 32% in sector's TFEC (vs. 28% in 2023) ✓ Continue current energy efficiency measures (standards, labelling) ✓ Introduction of clean hydrogen in specific subsectors | <ul style="list-style-type: none"> • Sector energy intensity of 15 MJ/USD • Electricity share: 27% in sector's TFEC • Bioenergy share: ~40% in sector's TFEC • Clean hydrogen share: 1% in sector's TFEC (direct uses in iron, steel and chemicals production) ✓ Introduction of CCS/BECCS in hard-to-abate sectors (e.g. cement, iron and steel) at end of decade |

BUILDINGS

| | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> • Floor area of 77 million (m²) (vs. 69 million m² in 2023) • Electricity share: 57% in sector's TFEC (vs. 51% in 2023) • Bioenergy share: 13% in sector's TFEC, mostly traditional biomass (vs. 18% in 2023) • Deployment of solar thermal energy (1% in TFEC) | <ul style="list-style-type: none"> • Floor area of 88 million m² • Electricity share: ~75% in sector's TFEC • Bioenergy share: <10% in sector's TFEC (>5% - traditional biomass) • Solar thermal energy share: 1% in sector's TFEC | <ul style="list-style-type: none"> • Floor area of > 98 million m² • Electricity share: >90% in sector's TFEC • Bioenergy share: <5% in sector's TFEC (1% - traditional biomass) • 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; CO₂ = carbon dioxide; m² = 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 rising four-fold, 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 |
| <ul style="list-style-type: none"> +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) | <ul style="list-style-type: none"> 3× solar PV, 3.2× onshore wind, +10% hydro (vs. 2030) | <ul style="list-style-type: none"> 2.3× solar PV, 1.7× onshore wind, +17% hydro (vs. 2040) |
| <ul style="list-style-type: none"> 91% RE in generation by 2030 | <ul style="list-style-type: none"> 97% RE in generation by 2040 | <ul style="list-style-type: none"> 98% RE in generation by 2050 |
| <ul style="list-style-type: none"> 58 GW Distributed generation by 2030 (vs. a total installed capacity of 35 GW in 2024) | <ul style="list-style-type: none"> 108.5 GW Distributed generation by 2040 | <ul style="list-style-type: none"> 237 GW Distributed generation by 2050 |
| <ul style="list-style-type: none"> Stronger regional interconnections for RE and hydro balancing | <ul style="list-style-type: none"> Grid modernisation with advanced digitalisation | <ul style="list-style-type: none"> Fully renewable, resilient grids via regional co-operation |
| <ul style="list-style-type: none"> USD 345 billion T&D investment by 2030 (compared to an estimated USD 30 billion per year in recent years) (IADB, 2024) | <ul style="list-style-type: none"> USD 1 039 billion T&D investment between 2031 and 2040 | <ul style="list-style-type: none"> USD 1 847 billion T&D investment between 2041 and 2050 |
| <ul style="list-style-type: none"> Energy storage to 11 GW (compared to approximately 1 GW total installed capacity in 2024) | <ul style="list-style-type: none"> Energy storage to 76 GW capacity | <ul style="list-style-type: none"> 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 |
| <ul style="list-style-type: none"> 43 billion L of bioethanol (vs. ~30 billion L in 2023) | <ul style="list-style-type: none"> 66 billion L of bioethanol | <ul style="list-style-type: none"> 82.5 billion L of bioethanol |
| <ul style="list-style-type: none"> 20 billion L of biodiesel (vs. 9.5 billion L in 2023) | <ul style="list-style-type: none"> 21 billion L of biodiesel | <ul style="list-style-type: none"> 14 billion L of biodiesel |
| <ul style="list-style-type: none"> 3 billion m³ biogas/biomethane | <ul style="list-style-type: none"> 16 billion m³ biogas/biomethane | <ul style="list-style-type: none"> 30 billion m³ biogas/biomethane |
| <ul style="list-style-type: none"> 6.3 EJ of bioenergy supply (vs. 4.6 EJ in 2023) | <ul style="list-style-type: none"> 10 EJ of bioenergy supply | <ul style="list-style-type: none"> 13 EJ of bioenergy supply |
| <ul style="list-style-type: none"> Share of 20% in TFEC (vs. 16% in 2023) | <ul style="list-style-type: none"> Share of >25% in TFEC | <ul style="list-style-type: none"> Share of 33% in TFEC |
| <ul style="list-style-type: none"> Share of 4% in electricity generation (vs. 5% in 2023) | <ul style="list-style-type: none"> Share of ~3% in electricity generation | <ul style="list-style-type: none"> Share of 2% in electricity generation |
| | | <ul style="list-style-type: none"> 420 Mt of cumulative captured CO₂ 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. CO₂ = carbon dioxide; EJ = exajoules; L = litres; m³ = 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 1300 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 |
| <ul style="list-style-type: none"> Production of 0.33 EJ in clean hydrogen (-3 MtH₂eq) | <ul style="list-style-type: none"> Production of 1.3 EJ in clean hydrogen (-11 MtH₂eq) | <ul style="list-style-type: none"> Production of 2.7 EJ in clean hydrogen (-22 MtH₂eq) |
| <ul style="list-style-type: none"> Electrolyser capacity of 32 GW | <ul style="list-style-type: none"> Electrolyser capacity of 130 GW | <ul style="list-style-type: none"> Electrolyser capacity of 260 GW |
| <ul style="list-style-type: none"> Hydrogen demand: 0.7 EJ (-6 MtH₂eq), with 3 Mt exported | <ul style="list-style-type: none"> Hydrogen demand: 1.8 EJ (-15 MtH₂eq), with 9 Mt exported | <ul style="list-style-type: none"> Hydrogen demand: 2.9 EJ (24 MtH₂eq), with 17 Mt exported |

Note: Clean hydrogen refers to blue and green type. Production of hydrogen in 2023 corresponded to 0.25 EJ (-2 MtH₂eq), mostly fossil-fuel based.
EJ = exajoules; H₂eq = 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 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 1240 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 Mt of H₂eq. 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 CO₂ 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.





IRENA

International Renewable Energy Agency

© IRENA 2025

www.irena.org