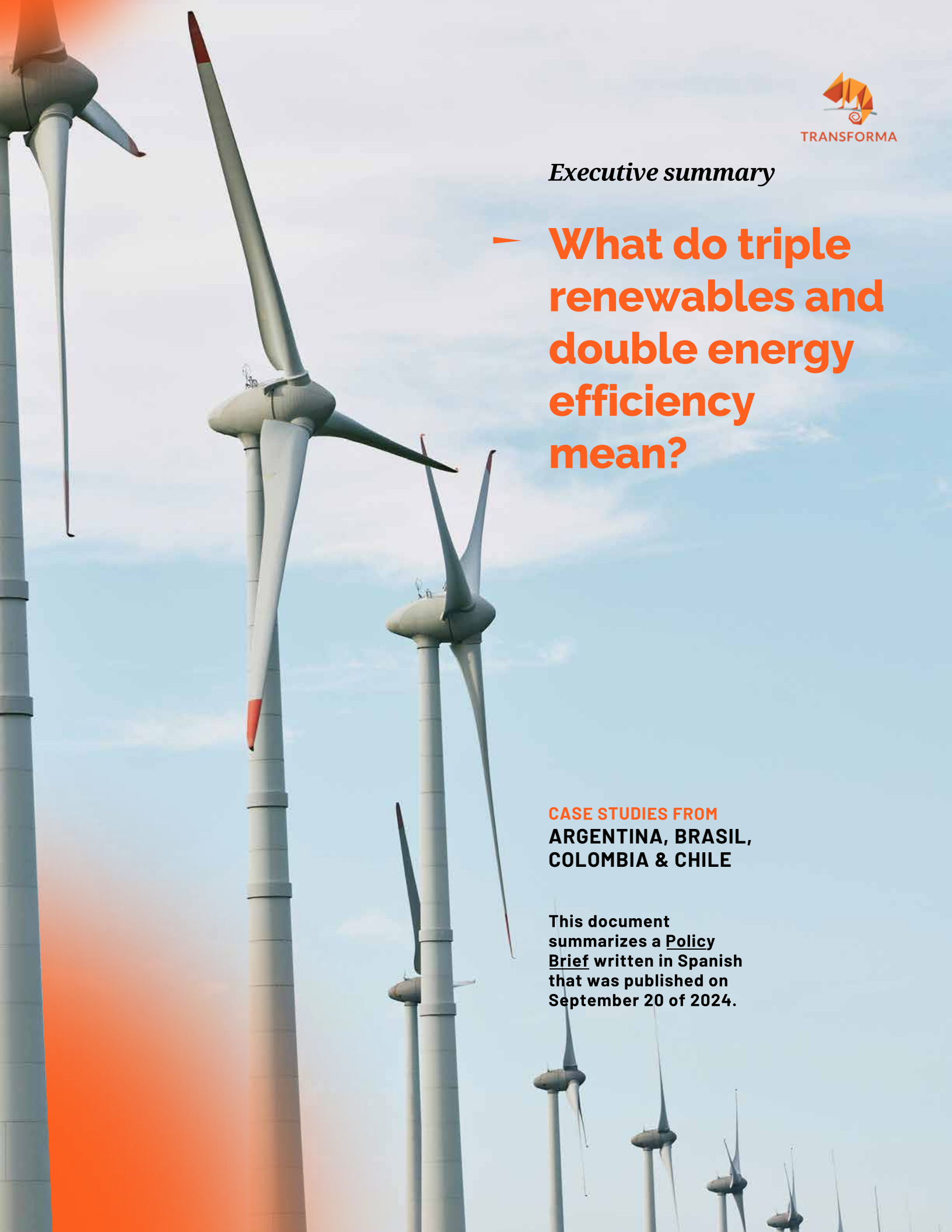


TRANSFORMA

Executive summary

What do triple renewables and double energy efficiency mean?

CASE STUDIES FROM
ARGENTINA, BRASIL, COLOMBIA & CHILE

This document summarizes a Policy Brief written in Spanish that was published on September 20 of 2024.

Introduction

How can Latin American countries contribute to the global target established in the Global Stock-take, of tripling renewable energy capacity and doubling the average annual rate of energy efficiency improvement?

The feasibility of tripling renewable energy capacity depends on the country's current electricity mix. For three out of the four countries assessed in our study—Colombia, Brazil, and Chile—where renewables already constitute a significant share of the electricity mix, it is unnecessary to literally triple the 2022 installed renewable capacity by 2030 (as the baseline year of the global target). Achieving such an increase would far surpass the countries' demand projections.

In Argentina's case, however, where renewables account for a much smaller share of the electricity system, tripling installed capacity could meet the projected electricity demand by 2030. However, this would require increasing the share of renewables from 37% to nearly 90% within just five years—a challenge that is virtually unattainable given current infrastructure and market constraints.

COLOMBIA, with its current renewable energy capacity of 13.75 GW, which represents 69.5% of the total capacity and an average expansion rate of 3.6% in the last 3 years, has the potential to expand this capacity by 1.6 times to reach 21.4 GW significantly. By increasing its renewable capacity at a steady rate of 5.6% annually, the country could achieve an 80% renewable energy installed capacity share by 2030, displacing 14% of its fossil fuel consumption for electricity generation.

ARGENTINA, with its current renewable energy capacity of 18.2 GW which represents 29% of the total capacity and an average expansion rate of 2.6% in the last 3 years, has the potential to expand this capacity by 1.48 times to reach 23.5 GW significantly. By expanding its renewable capacity at a steady rate of 3.27% annually, the country could achieve a 40% renewable energy installed capacity share by 2030, displacing 3.6% of its fossil fuel consumption for electricity generation.

BRAZIL, with its current renewable energy capacity of 178 GW which represents 88% of the total capacity and an average expansion rate of 5.91% in the last 3 years, has the potential to expand this capacity by 1.6 times to reach 276.9 GW significantly. By increasing its renewable capacity at a steady rate of 6.3% annually, the country could achieve a 96% renewable energy installed capacity share by 2030, displacing 10% of its fossil fuel consumption for electricity generation.

CHILE, with its current renewable energy capacity of 19.9 GW which represents 53% of the total capacity and an average expansion rate of 5.98% in the last 3 years, has the

potential to expand this capacity by 2.3 times to reach 47 GW significantly. By expanding its renewable capacity at a steady rate of 7.45% annually, the country could achieve a 96% renewable energy installed capacity share by 2030, displacing 31% of its fossil fuel consumption for electricity generation.

All countries have the potential for this renewable growth from large-scale solar and onshore wind, but each one has other renewables at their disposal. Distributed solar will contribute the most to Brazil and Argentina's expansion. With a secondary role, bioenergy will be used in all four countries, and to diversify further, Chile will have a contribution from geothermal energy and Argentina from small-scale hydropower. Adding to the global target, doubling energy efficiency will allow the four countries to save 16.81 GW in electricity generation required installed capacity.

Chapter 1.
Modeling methodology

For Latin American countries, tripling and doubling global targets can be framed in the following modeling scenarios conducted by Transforma using the EnergyScope tool. This approach optimizes costs and identifies the most favorable technology mix for each country. One of the scenarios, called the "sustainable progression" scenario, revealed the previously mentioned key insights on the minimum potential contributions to global goals (results are not trying to align with 1.5 ºC trajectories but can be seen as a milestone in the 2050 net zero trajectories).

Three main scenarios were built for the four countries:

- **Tripling Scenario:** This is a threefold increase in the current installed capacity of renewable energies in electricity generation (base year 2022), literally meeting the global target of tripling renewable.

- **Increase in Renewables Scenario:** Models the necessary expansion in installed renewable energy capacity to meet projected energy demand by 2030.

- **Sustainable Progression of Renewables Scenario:** Models the most cost-efficient installed capacity to meet projected energy demand to 2030. Also includes energy savings due to a doubling increase in the rate of improvement in energy efficiency in electricity generation systems, through energy intensity for the residential and industrial sector.

Other 3 scenarios were modeled:

- The **Accelerated Progression scenario** was modeled for Colombia and Argentina, and explores a more ambitious trajectory of incorporating renewable energies, based on the scenario of sustainable progression.

- The **RELAC scenario** was modeled for Colombia and Chile, who have acquired commitments to increase renewables under the Renewables for Latin America and the Caribbean (RELAC) initiative.

- The **JET-Minminas scenario** was built for Colombia as a comparative measure of the current government's roadmap for developing a Just Energy Transition.

The balance between supply and demand in each scenario was analyzed according to each country's current goals, ensuring that the system can maintain the energy balance between 2024 and 2030. Given that costs are optimized in the modeling, the entry of renewables does not imply that by 2030, fossil fuels used for electricity generation will be totally displaced.

Except for the accelerated demand projection presented for Colombia, the countries' demand scenarios do not contemplate a massive electrification of the economy.

For the modeling, input conditions, assumptions, model constraints and limitations were defined in the full

document (originally written in spanish) in section 1.2; Annex 1 describes the ***EnergyScope*** structure and modeling conditions in the context of this exercise for each country. Annex 2 presents the input parameters such as projected and observed energy demand in 2022, total installed and renewable energy capacity in 2022, energy potential in 2023, and observed rates of energy efficiency improvement.

Chapter 2.
Colombia

GUATAPÉ, ANTIOQUIA

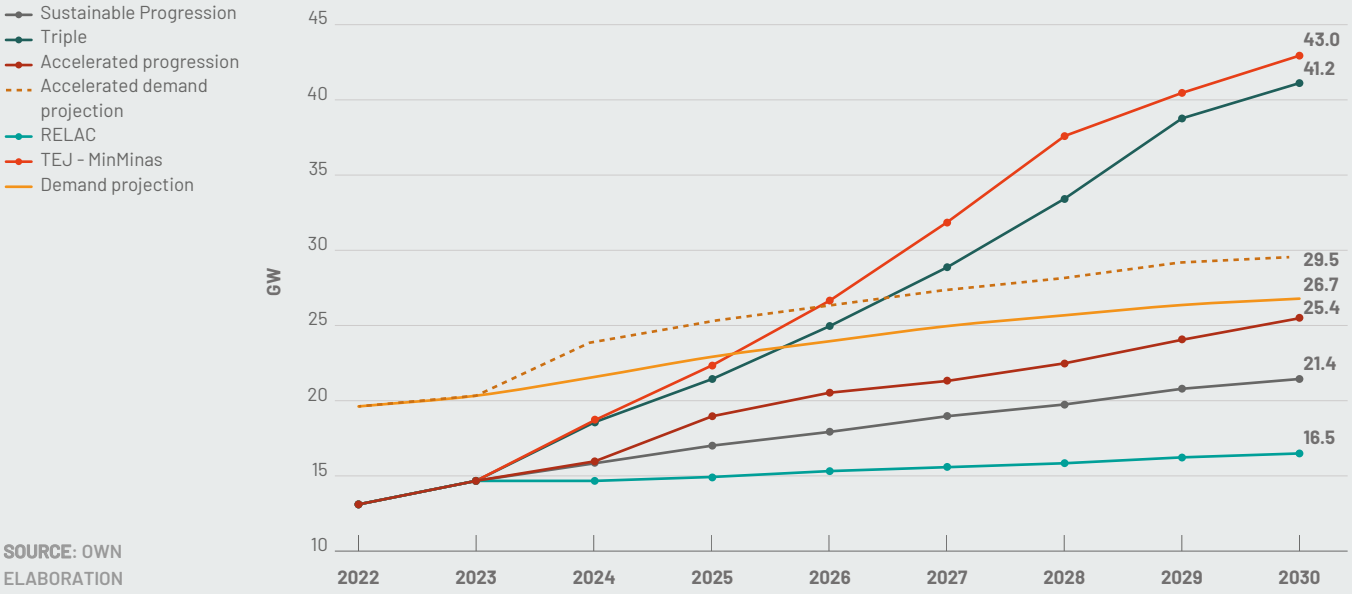
In terms of 2022 installed electric capacity, hydroelectricity leads with 66.9%, followed by natural gas (15.3%), coal (8.8%), and other fossil fuels (6.3%). Non-hydro renewables, such as solar (1.5%), biomass (1.1%), and wind (0.02%), have minor contributions.

The "tripling" scenario would far exceed what is required to meet projected electricity demand by 2030. Therefore, considering a tripling of the installed capacity of renewable energies in Colombia is not feasible, especially considering that renewable sources such as hydroelectric power already have a high share in electricity generation.

In **the "sustainable progression" scenario**, hydroelectricity would continue to dominate the electricity mix, accounting for 70.6% of installed capacity in 2030 but with no new installed capacity in the coming years. Solar energy is key, reaching 14.5% of the mix with an installed capacity of 3 GW. Onshore wind energy would also show significant growth, reaching 9.3% with a projected capacity of 2 GW. Bioenergy, with a 5.6% share, would diversify the energy system.

Also in this scenario, the increase in energy efficiency from 2% to 4% generates an aggregate savings of 0.87 GW in installed electricity generation capacity by 2030. These savings are distributed in: hydro 0.614 GW, bioenergy 0.040 GW, large-scale solar 0.120 GW, distributed solar 0.004 GW, solar thermal: 0.008 GW and onshore wind 0.080 GW.

FIGURE 1. MODELED SCENARIOS FOR COLOMBIA BY 2030

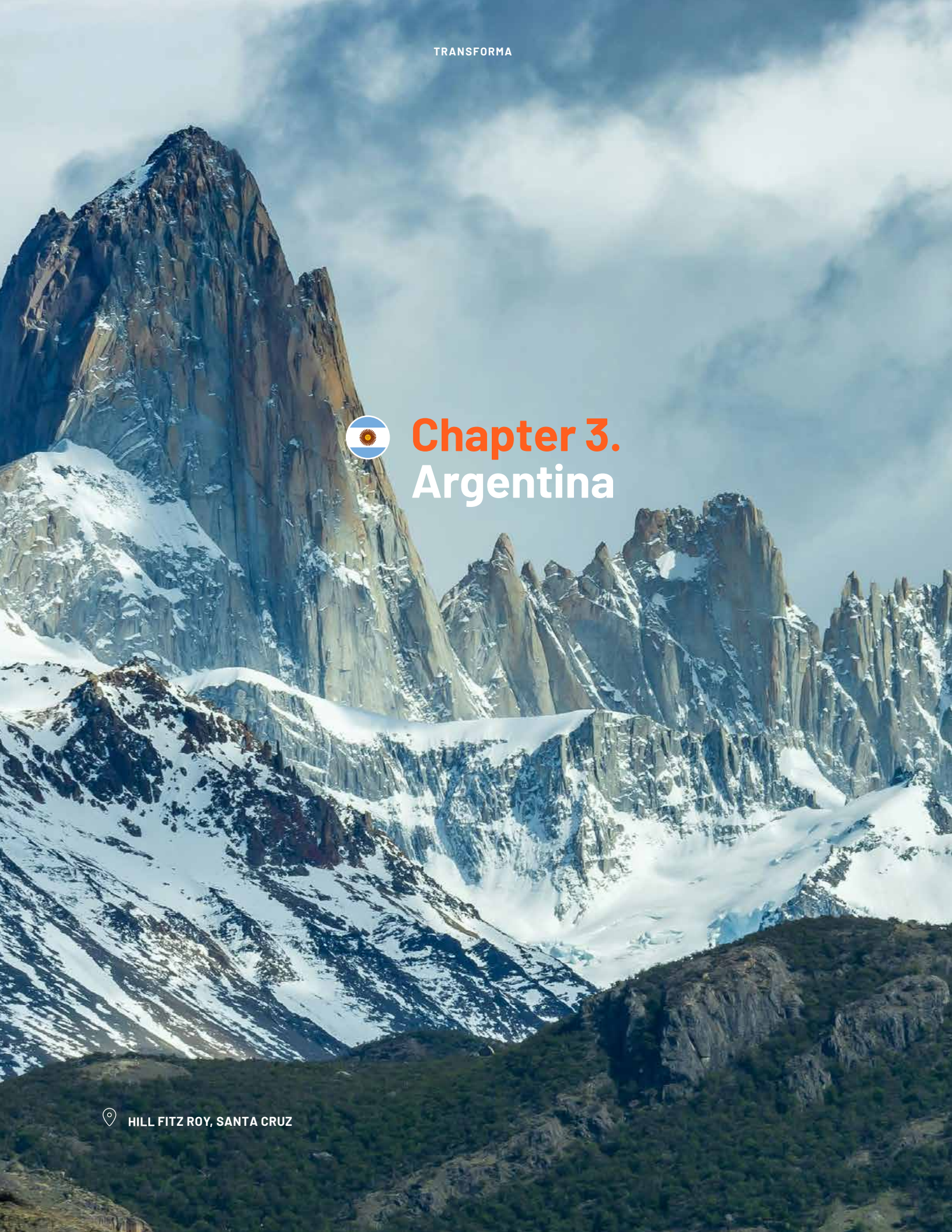


SOURCE: OWN ELABORATION

The **"accelerated sustainable progression" scenario** presents a perspective in which installed renewable energy capacity growth is expected to respond to accelerated energy demand due to electrification decisions on a larger scale than expected.

The Colombian government (TEJ-MinMinas scenario) has set an ambition far exceeding the projections proposed in the sustainable progression scenario, showing the feasibility of achieving the modeled objectives.

The energy transition in Colombia towards renewable sources such as bioenergy, solar and wind, presents a significant opportunity to reduce GHG emissions in the electricity sector. In the sustainable progression scenario projected to 2030, a 21.3% decrease in GHG emissions is estimated for this decade.



Chapter 3.
Argentina

HILL FITZ ROY, SANTA CRUZ

In 2022, fossil fuels contributed 59% to the electricity mix, followed by hydroelectric (26%), wind energy (8%), nuclear (4%), solar (3%), and a smaller contribution of biofuels. In contrast, fossil fuels account for three-quarters of the energy mix, with natural gas (49.7%) and oil (37.5%).

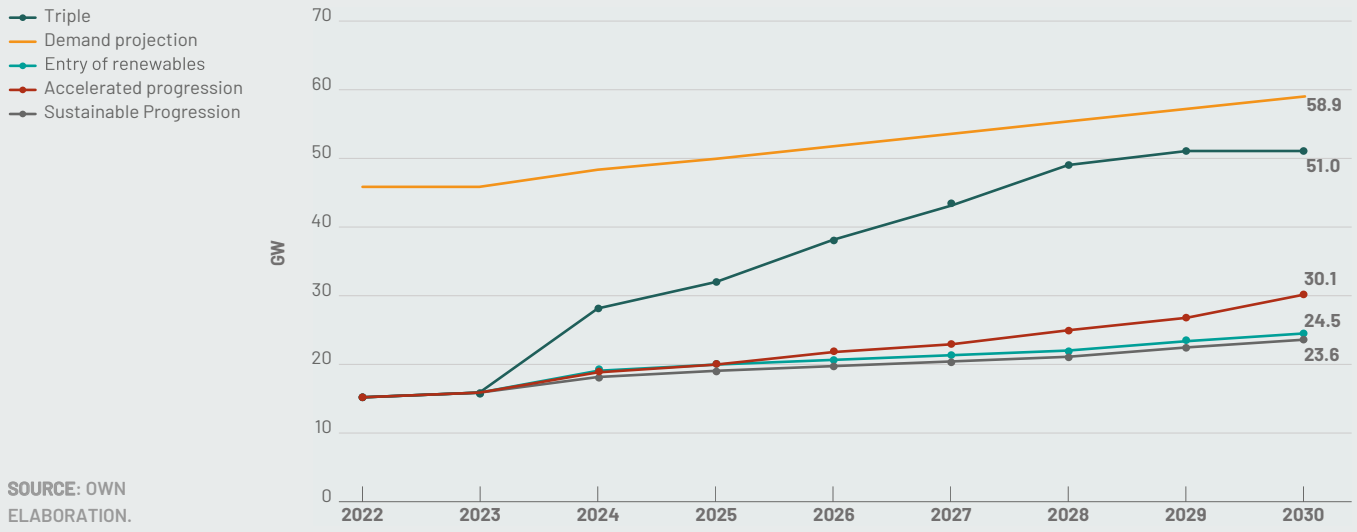
In the **"tripling" scenario** a significant increase in installed renewable energy capacity is projected, allowing for a considerable contribution to the global renewable energy target. Given that the current share of renewables in their electricity mix is much lower (37.4%) than the other countries analyzed, to comply with a strict definition of tripling renewable energies, it would be necessary to reach an installed capacity for electricity generation close to 90% in 6 years, which would require an enormous effort for the country, and make this scenario unfeasible.

In the **"sustainable progression" scenario,** hydroelectricity will remain the main energy source in Argentina's electricity mix, contributing 57.1% and 13.46 GW of installed capacity by 2030. Some small-scale hydroelectric projects (0.9 GW) are foreseen. The solar potential allows large-scale projects to add 3 GW and distributed solar energy with 1.5 GW, reaching 18.3% of the mix by 2030. In addition, some 5 GW of wind power representing 20.4% of the mix. Finally bioenergy would allow reaching 1 GW of installed capacity, equivalent to 4.1% of the electricity mix in 2030.

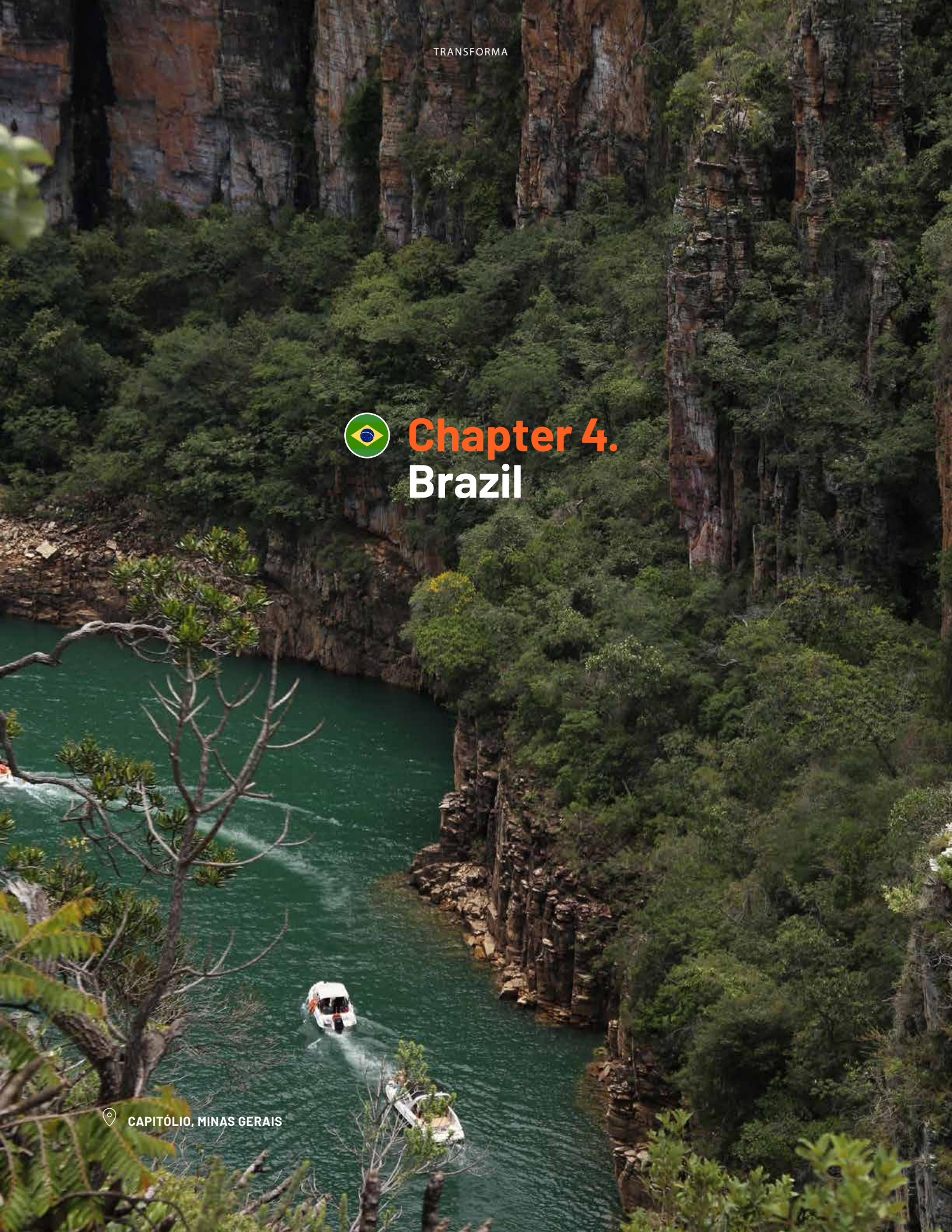
In the same scenario, an energy efficiency improvement rate from 1.8% in 2023 to 3.6% in 2030, translates into total savings of 0.94 GW at the end of this decade, which would be distributed as follows: Hydroelectric: 0.53 GW, Bioenergy: 0.04 GW, Large-scale solar energy: 0.12 GW, Distributed solar energy: 0.06 GW, Onshore wind energy: 0.19 GW.

The incorporation of renewable energy sources into the Argentine electricity system has the potential to achieve a significant reduction in greenhouse gas emissions, estimated at 7.9% by 2030.

FIGURE 2. MODELED SCENARIOS FOR ARGENTINA BY 2030



SOURCE: OWN ELABORATION.



Chapter 4.
Brazil

CAPITÓLIO, MINAS GERAIS

A third of Brazil's energy mix for 2022 is oil and biofuels, followed by 12.3% of hydro energy, 9.4% natural gas and 4.7% coal. Just 3.5% of the energy mix is based on renewable sources. The electricity mix is mainly supplied by hydroelectric (52.5%), making Brazil the second largest country in hydroenergy production and solar and wind renewable energies represent 35.5%, hydropower 25.1% and fossil fuels 39.4%

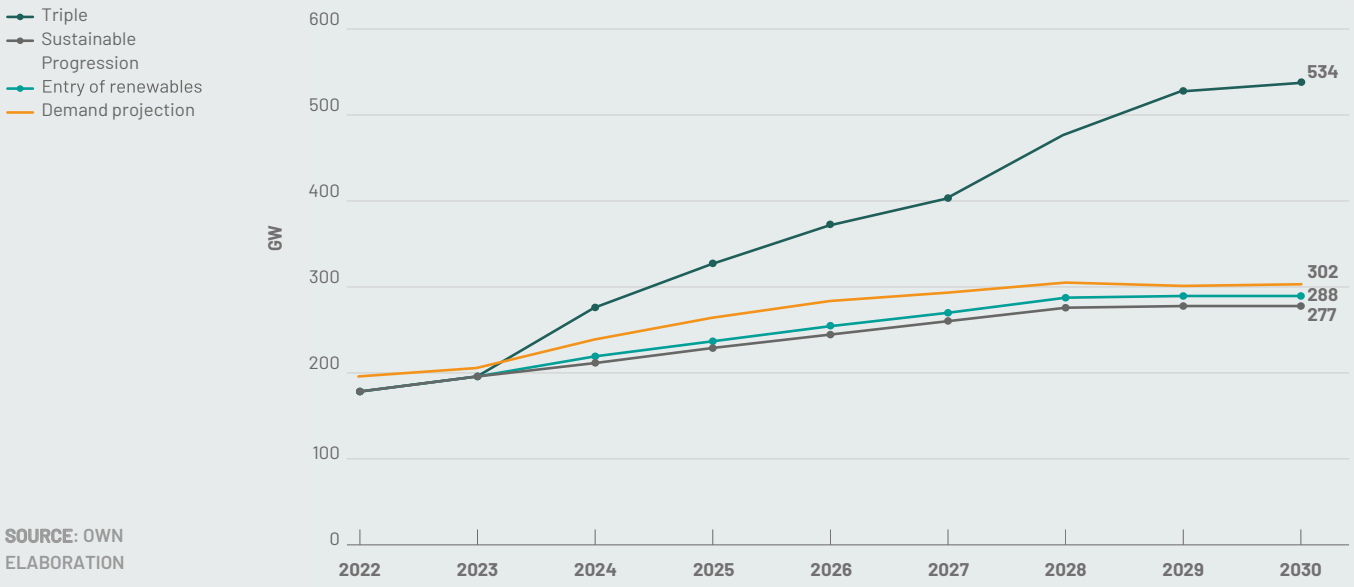
In the **"tripling" scenario**, renewable capacity would reach 524 GW, exceeding Brazil's projected energy demand. Given the current 88% share of renewables in power generation, a literal tripling may be unnecessary.

In the **"sustainable progression" scenario** doubling energy efficiency reduces total demand, creating energy savings across hydropower, large-scale and distributed solar, and onshore wind. The projected energy mix by 2030 will be led by solar power at 40.3%, followed by hydropower at 38.9%, wind at 14.2%, and bioenergy at 6.6%.

Brazil must expand capacity to meet projected demand by prioritizing the diversification of renewables like bioenergy, solar, and wind. It must also phase out fossil fuels, avoid new coal plants, and limit natural gas expansion to protect its renewable-based mix and reduce climate vulnerability.

The incorporation of renewable energy sources into the Brazil electricity system has the potential to achieve a reduction in greenhouse gas emissions, estimated at 6.8% by 2030.

FIGURE 3. MODELED SCENARIOS FOR BRAZIL BY 2030



SOURCE: OWN ELABORATION

Chapter 5.
Chile

LOS FLAMENCOS NATIONAL RESERVE, ANTOFAGASTA

Chile's energy mix for 2022 was based on fossil fuels, with 72% participation of oil, natural gas, and coal. Biofuels, hydro, solar, and wind energies cover the remaining mix. For the electricity mix, solar and wind represent 35%, hydropower 25.1%, and fossil fuels 39%.

The **“tripling” scenario** would exceed what is required to meet projected electricity demand by 2030, with 2028 being the first year when energy supply starts exceeding energy demand. This highlights a need for faster renewable expansion compared to Brazil or Colombia.

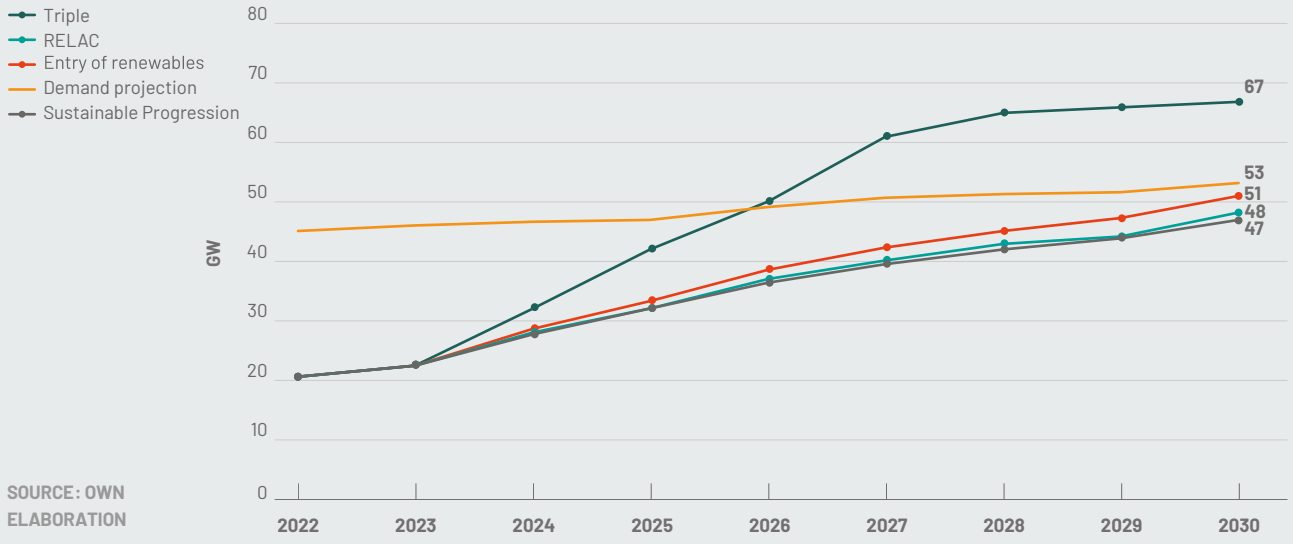
In the **"sustainable progression" scenario**, efficiency gains enable 47.1 GW of renewable capacity, reducing costs and resource demand compared to the 51 GW needed in other scenarios.

By 2030, renewables could comprise 96% of Chile's electricity mix, led by large-scale solar (48.7%) and onshore wind (30.4%), while hydropower’s share decreases to 14.1%.

Efficiency improvements save 3.92 GW of capacity across large scale solar (1.87 GW), wind (1.19 GW), and hydropower (0.55 GW); minor but important savings would be achieved in geothermal (0.024 GW), bioenergy (0.076 GW), distributed solar energy (0.092 GW) and solar thermal energy (0.11 GW).

The incorporation of renewable energy sources into the Chile electricity system has the potential to achieve a reduction in greenhouse gas emissions, estimated at 40.9% by 2030.

FIGURE 4. MODELED SCENARIOS FOR CHILE BY 2030



SOURCE: OWN ELABORATION

Chapter 6.
Regional comparative analysis

Between 1990 and 2022, renewable electricity generation increased by 128% in Colombia, 136% in Argentina, 182% in Brazil, and a significant 390% in Chile. Brazil had the largest nominal growth but started with a higher installed capacity than the other countries.

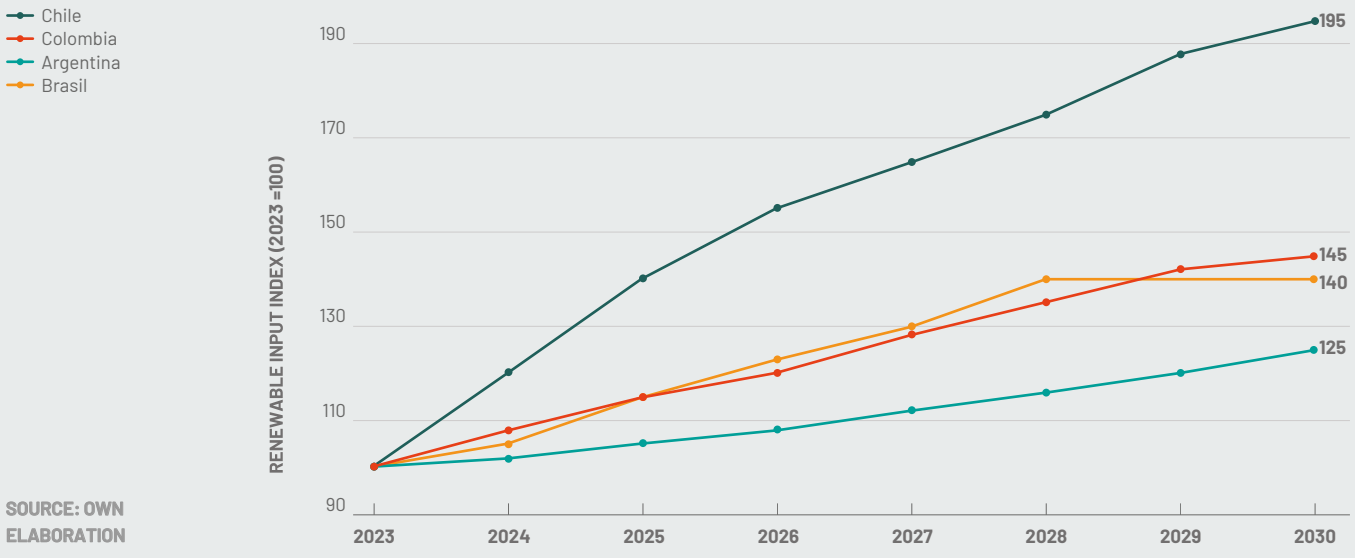
From 2000 to 2022, renewable energy generation in Latin America grew by 59.2%, with all four countries surpassing the regional average. However, Chile consistently increased its renewable electricity generation, aligning with its national goals, while Brazil underwent fluctuating growth, including a 3% decline in 2021, likely due to political and climate factors.

Hydropower challenges, like climate variability and environmental impacts, could be handled with solar and wind, which are now more cost-effective, enabling a shift towards 75% renewable electricity generation by 2030 and reducing fossil fuel use by 15%.

To compare the four countries, an index was built, given the different starting points of each, the result is presented in the following figure 5, Chile has the potential to carry out a significant expansion, practically doubling its index. Colombia and Brazil, on the other hand, are making similar efforts that allow them to move towards an ambitious scenario, although slightly more conservative than Chile's, especially in terms of diversification of renewable sources other than hydro.

Also as shown in Figure 5, in the case of Argentina, the increase in renewable energies would be lower compared to the other three countries analyzed, considering that the country has an electricity mix dependent on fossil fuels and with conditions for the use of gas as fuel for electricity generation at a very low cost.

FIGURE 5. EVOLUTION OF THE INFLOW OF RENEWABLES IN THE CASE STUDIES (INDEX=100)



SOURCE: OWN ELABORATION

Chile has clear energy efficiency targets, while Colombia, Brazil, and Argentina face challenges like the need for specific goals, robust regulatory frameworks, and dedicated agencies, hindering progress in energy efficiency across the region.

The 2023 IRENA report shows a significant decline in renewable energy generation costs, driven by innovation, economies of scale, and competition. Solar photovoltaic and onshore wind costs dropped by 90% and 70% since 2009, respectively. Projections to 2050 indicate continued cost reductions, making renewables increasingly competitive with conventional energy sources.

Chapter 7. Key recommendations

- Increase the ambition of renewables penetration and support the scope or close the gap with respect to the targets set by the countries. Also the findings of this document can guide the targets in terms of amount of installed capacity and sources, to establish goals in line with each country's capabilities and needs.

- Identify the financing required to meet projected renewable and energy efficiency goals. The governments of the region's countries must not only support the mobilization of public funds to promote renewable energies, but must also generate a reliable environment to attract private investment.

- Given that the signatory countries of the Paris Agreement must submit, by 2025 at the latest, the update of their NDCs for 2030 and the formulation of new NDCs with a horizon towards 2035, it is recommended that LAC countries include targets for tripling renewable energy capacity and doubling energy efficiency targets (contextualized to country circumstances) in the NDCs.

- Strengthen current regulatory frameworks and public policies regarding the prioritization of energy sources to be developed and energy efficiency. Governments should also work on mechanisms that guarantee the continuity of processes related to the entry of renewable energies, despite political changes.

- Ensure that both the transition to and deployment of renewable energy include a robust fairness and equity component. In order for the transition to renewable energies to be fair and equitable, the communities living around a renewable energy project (especially local and indigenous communities) must be guaranteed the right of access to information and active participation in order to ensure transparency in the decision-making process. Along these lines, it is essential that the communities involved receive equitable access to the resources and benefits derived from renewable energy projects.

- It is important that industrial policies are strengthened to at least support research and development (R & D) to improve the efficiency and competitiveness of the renewable energy value chain, and to provide training and capacity building programs for workers, including the communities where renewable energy plants are to be located.

- Learning from the experience of other more advanced countries in the region accelerates our progress towards the goal and reduces losses due to inefficient processes or poorly focused programs. Also, it is possible to join efforts and articulate collective goals with a view to strengthening the region as a key player in the just energy transition.

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SEPTEMBER 2024

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