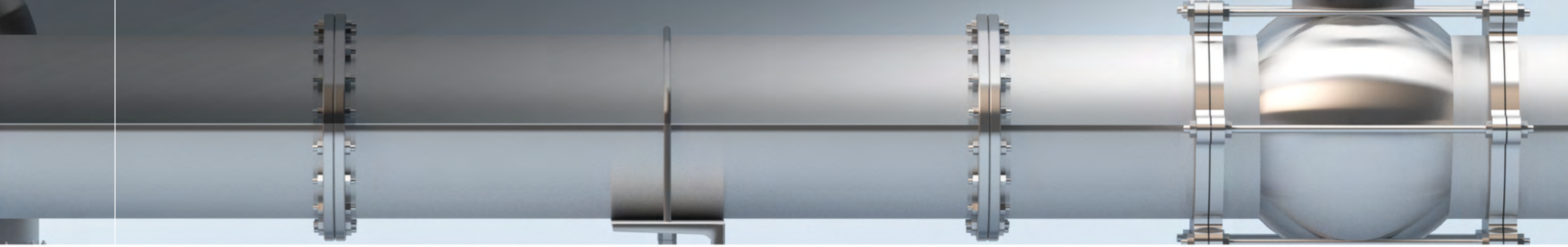
WHITE PAPER

Natural Gas in the Transition to Low-Carbon Economies

The Case for Latin America and the Caribbean

APRIL 2023



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Foreword

This document provides an overview of the role of natural gas, complemented by lower carbon/green gases, in the energy transition in the specific context of Latin America and the Caribbean. It aims to contribute to the international energy dialogue, to help in the understanding of the critical benefits that gases can bring to the energy transition, and to provide evidence and insights to inform energy stakeholders about the unique opportunities and challenges of this important region. The global energy and food shortages of the past year have shown that the market will respond quickly to price signals – for example by rapidly increasing LNG exports to Western Europe by 66% in 2022 – but those high prices have been devastating to consumers at all levels.

Factories have closed, businesses have cut back activity, individuals and families have had to resort to food banks in unprecedented numbers. One lesson from last year has been that policymakers need to pay closer attention to balancing the clear need for climate action with the imperatives of energy security and energy access.

Renewables certainly need more investment, but it is concerning that while governments are not making those investments at the rate and scale required, they are also neglecting indigenous supplies of natural gas that could fuel poverty alleviation, and business and community development. With the world's population estimated to expand by more than 2 billion people by 2050 energy demand is in danger of growing faster than low-carbon energy deployment, resulting in more coal consumption and far higher greenhouse emissions of both carbon dioxide and methane.

The challenge for countries in this region is much greater than for those in the developed world. Firstly, in terms of financing costs and secondly, because the distribution of subsidies to technologies that are not ready bankable, competes with other essential priorities, such as health, education and pensions.

Energy policy for the region therefore needs to become more pragmatic than it has been, with greater focus on long term security of supply balanced against the urgency of a just energy transition that recognizes intra-regional diversity.

Natural gas, and other low carbon gases are invaluable tools for the region to reach a net zero future, while avoiding volatility and economic hardship and investment in new supply must not only continue, but grow.

Milton Catelin
Secretary General
IGU

The oil and gas industry of Latin America and the Caribbean shares the communal sense of urgency for curbing the projected effects of global climate change, by transitioning our regional primary matrix to being even further weighted by renewable and low-emission energy sources. ARPEL has undertaken as a mission to drive the necessary transformation of the sector in this region and has incorporated renewable energy into its scope.

Being an eclectic region, we also understand that transitions need to be just and bespoke to national and even local energy structure, development, and poverty situations. These transition paths are naturally hindered by complexities and uncertainties, such as assuring energy security and sovereignty in a scenario of growing populations and economies, diverse levels of vulnerability to climate change, and differing hierarchies of national and social priorities.

As it names implies, transition doesn't mean abrupt replacement. It entails having the necessary realism and pragmatism to seek synergies and "quick wins" towards the decarbonization goals. Natural gas is thus an ideal transition fuel to fill the gap between energy demand and renewable and low emissions supply: by gradually displacing coal and heavier petroleum-derived fuels; by extrapolating its competencies and infrastructure to CCUS, biomethane and hydrogen; and by providing a synergistic uninterruptible, technologically available and deliverable, reliable, and economically accessible basis to solar and wind, for example. Where there is no rain, sunshine or wind, our natural gas will still be there.

Carlos Garibaldi
Executive Secretary
ARPEL

This work seeks to provide an outline of the role of natural gas and other low carbon gases in the different transitions that are taking place in Latin America and the Caribbean. Transitions, as a plural, is a key concept to acknowledge the diversity of our regional context.

Natural gas is, for some countries in our region, the privileged way towards a lower carbon matrix. Energy transitions towards cleaner energy systems have natural gas as a key resource in order to achieve the reduction of greenhouse-gas emissions and the improvement of the air quality of our cities without penalizing consumption, production and employment in economies hardly hit by the pandemic and the global energy crisis.

The complementation that existing natural gas infrastructure provides to the intermittence of renewable energy sources is paramount to the long term energy security of Latin America and the Caribbean. Advancing regional integration in natural gas with new infrastructure will only strengthen the reliability and dependability of our energy systems.

Our region still struggles with poverty, low growth and investment and lack of energy access. Natural gas can provide a low-cost energy source that enhances competitiveness and brings about higher rates of economic growth while extending the reach of clean fuels for cooking and reducing emissions of greenhouse gases and particulate material.

Andrés Rebolledo
Executive Secretary
OLADE

ARPEL

ARPEL, is a non-profit association gathering oil, gas, and renewable energy sector companies and institutions in Latin America and the Caribbean. Founded in 1965 as a vehicle of cooperation and reciprocal assistance among sector companies, its main purpose is to actively contribute to industry integration and competitive growth, and to sustainable energy development in the region. Its membership currently represents a high percentage of the upstream and downstream activities in Latin America and the Caribbean and includes national and international operating companies, providers of technology, goods and services for the value chain, and national and international sector institutions. Since 1976, ARPEL has held Special Consultative Status with the United Nations Economic and Social Council (ECOSOC). In 2006, the association declared its adherence to the UN Global Compact principles.

IGU

IGU was founded in 1931 and is a worldwide non-profit organization representing more than 150 gas and related service industry members worldwide on all continents. The members of IGU are national associations and corporations within the gas industry and related services worldwide, covering over 90% of the global gas market and working in every segment of the gas value chain, from the supply of natural and decarbonized gas, renewable gas, and hydrogen, through their transmission and distribution, and all the way to the point of use. IGU holds the status of UNFCCC non-governmental organization observer at the UN Climate Change Conferences (Conference of the Parties) and has participated in every conference from COP1 to COP27.

OLADE

OLADE, the intergovernmental body of cooperation, coordination and technical advisory of the energy public sector of Latin America and the Caribbean was established in 1973 by the signing of the Lima Agreement, ratified by 27 countries in Latin America and the Caribbean, with the fundamental objective of promoting the integration, conservation, rational use, commercialization, and defense of the region’s energy resources.

Executive Summary

The world needs a massive transformation, and natural gas is essential for it

The world needs to transition to low-carbon economies to reduce global warming while continuing to promote sustainable socio-economic development for a growing global population. Achieving this massive goal requires a radical transformation in how energy is supplied and used worldwide, as 73% of global greenhouse gas (GHG) emissions are generated by energy use, particularly by burning fossil fuels, representing roughly 80% of the world's primary energy supply. Transforming the energy sector at the needed scale and pace is a herculean task, to which all the players in the energy landscape must contribute, while recognizing that the transition will require different pathways and options for different conditions, thus being indeed "transitions" rather than a unique linear sequence.

Additionally, widespread poverty and population growth urge us to look at energy security, food security, and affordability as cornerstones of the current debate, where socio-economic development is an essential aspect in developing and low-income countries; all of them are being negatively affected by the ongoing crisis.

This white paper provides a strategic approach to the role of and critical drivers for the development of natural gas today (complemented by lower-carbon/green gases in the medium term) in the energy transition in the specific context of Latin America and the Caribbean. It aims to contribute to the international energy dialogue, to help in the understanding of the critical benefits that natural gas could bring to the energy transition, and to provide evidence and insights to inform energy stakeholders about the regional situation in particular.

Collaboration, pragmatism, and putting people first are paramount to accelerating the transition

The four main pillars this white paper is focusing on are the following:

1. Transition success is based on both decarbonization and socio-economic development;

2. The transition is a complex process that needs profound social, economic, and technological country-specific transformations;

3. There is no single transition pathway, and this process must be just (linked to starting point circumstance) and people-centered to be acceptable and successful;

4. Defining balanced, timely, effective, and consistent transition pathways needs collaboration between all stakeholders and high levels of pragmatism.

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The future of the energy mix is deeply uncertain

The future of energy is thus highly uncertain. While the driving force of climate change and the consequent need to transition to a low-carbon energy system are evident, the nature of the mix in the decades to come looks much more indeterminate, mainly because it is not possible to accurately predict how and when alternative technologies will mature, reach the commercial stage, and achieve wide-ranging deployment. This paper considers the scenarios prepared by the most reputable international organizations to shed some light on the future of natural gas. Some of the key messages extracted from this global scale analysis are the following:

- Energy demand will most likely increase, driven by population growth compounded by economic development, even considering improvements in energy efficiency;

- Regarding the role of different sources in the future energy mix, there is uncertainty about how to fill the gap between supply and demand, and there is no alignment on the share that natural gas will represent. However, up to now, all the scenarios still contemplate the participation of coal and other fuels with a worse carbon footprint than natural gas, which drives us to envision other alternative scenarios. Additionally, there is the need to evaluate what-if scenarios, mainly in view of new constraints of minerals and metals in terms of both enhanced suitable supply and diversification;

- Some almost certain things can be stated; firstly, there will be advantages for the development of low-carbon gases such as biomethane, hydrogen (blue, green, and turquoise), and natural gas with carbon capture, utilization, and storage (CCUS) as part of all scenarios, with a growing contribution;

- The role of fertilizers will be heightened in the coming years by population growth and in particular, by nitrogen fertilizers using hydrogen as feedstock. On the other hand, the possible roles of hydrogen as a carrier and its use in biofuels and synthetic fuels open a new competition front for the fertilizer industry. In brief, to keep food prices affordable, all low-carbon hydrogen technologies should be considered;

- Furthermore, the natural gas industry should strive to “green” natural gas, developing new alternatives and reducing the carbon footprint of current operations, especially by reducing methane emissions, which is a win-win both from the climate and the economic perspectives;

- Besides, natural gas demand will most likely grow in the developing world, particularly in Asia. In contrast, the developed world is expected to decelerate fossil fuel demand, driven by more stringent climate policies;

- LNG trade and infrastructure are expected to grow further, adding flexibility and security to the energy supply while opening opportunities for developing other markets, such as bunkering. Latin American and Caribbean countries could take advantage of the current window of opportunity to foster the creation of a regional market by promoting the appropriate conditions for investment in exploration and production (E&P) and gas infrastructures to support market needs. In countries enjoying natural gas resources in the Latin America and Caribbean region, the promotion of best practices for additional E&P investments could also be a strong lever to support public finance equilibrium.

The transition must be accelerated, but as alternative options are not yet fully scalable, there are considerable risks of unintended consequences

As stated above, energy demand is expected to grow in the coming decades, opening a gap between energy supply and demand that must be filled with different energy sources. How this gap will be bridged is far from being neutral. While renewable energies have been rapidly gaining market share in the global energy supply, mainly in the power sector, these alternative low-carbon solutions are not yet mature enough to fill the expected gap between supply and demand for many very well-known reasons, such as technology readiness, infrastructure development, or potential supply chain bottlenecks.

While investment should be fostered to overcome these challenges, it should be acknowledged that they will not be solved at the needed pace, so part of the gap will need to be covered with natural gas as a substitute for coal and increasingly lower-carbon gases. Accepting this fact would lead to more balanced, pragmatic, realistic, and thus effective transition pathways, as putting too much pressure on unrealistic pathways could lead to bottlenecks that may finally favor more carbon-intensive alternatives, thus delaying the transition.

Besides, the challenge for developing and low-income countries is much greater than for developed ones, firstly in terms of financing costs and secondly, because the distribution of subsidies to technologies that are not ready bankable competes with other essential priorities, such as health, education, and pensions.

Decarbonization in Latin America and the Caribbean is not only a matter of energy

The region contributes approximately 8% of the world's total GHG emissions annually; however, less than half of these emissions are derived from energy use. Energy use accounts for only 43% of Latin American and Caribbean GHG emissions, a distinctive emissions profile (vis-à-vis 73% globally). The limited energy contribution is driven by electricity with low-carbon intensity, typically with a much larger share of hydropower and natural gas, than of coal. Other sectors such as agriculture, a very important economic activity in many countries, and land use changes, mainly because of the deforestation of the Amazon rainforest, have a greater impact than energy use, accounting for 45% of total GHG emissions. This fact greatly impacts energy policy, climate action, and decarbonization priorities. Latin American and Caribbean countries must thus build their own climate agendas for the energy sector, balancing economic development and decarbonization at the global scale.

Latin America and the Caribbean falls behind in terms of economic development, but monetization of natural gas resources can lead to greater prosperity

Latin America and the Caribbean is a vast and heterogeneous region, where most countries are rated as middle to low-income by the World Bank. Poverty and inequality are by far two of the most critical socio-economic challenges in the region. According to the Economic Commission for Latin America and the Caribbean (ECLAC), one-third of the region's more than 650 million inhabitants live in poverty, 13% in extreme poverty, and there are high levels of inequality.

However, the region is rich in natural gas resources and the natural gas sector is well-established in many countries, making significant contributions to GDP, foreign investment, job creation, and social welfare. In this paper, many monetization opportunities and success stories are highlighted. Countries such as Trinidad & Tobago, Peru, and Bolivia, have shown tremendous economic growth in the last two decades thanks to export-led developments of natural gas resources, the first two integrated into the global market via LNG and the latter via pipelines to neighboring countries. The Vaca Muerta play, in the Neuquen basin in Argentina, is a massive unconventional reservoir successfully being developed that has attracted US$20 billion in investments and has the potential to make Argentina the next major LNG exporting country. Brazil shows opportunities in the pre-salt region, Colombia has demonstrated the positive role of a strong gas penetration and has excellent promise in its recent offshore discoveries, while Guyana and Suriname are the two rising stars of the oil and gas industry because of massive discoveries that have been made offshore, opening the opportunity for dramatically boosting their economies.

There is a window of opportunity to monetize natural gas resources in Latin America and the Caribbean, contributing to the decarbonization of some sectors of the region and the main emitting regions in the world. For this purpose, the role of public and private companies — local and international — is crucial, as are the contributions of policymakers and regulators, accelerating the regulatory development that creates a stable framework to attract investment to the region.

Energy transitions should not be neutral to their impacts in poverty and inequality. Just transitions need to be deployed. For Latin America and the Caribbean, this means taking advantage of natural gas resources to contribute to economic diversification, sustainable growth, and energy transition.

Latin America and the Caribbean natural gas can help to phase-out coal in power generation globally and enable renewables in the region

Coal still represents 43% of the primary energy supply for power generation globally, mainly driven by four large countries: China, India, the USA, and Russia. In 2021, 51% of additional power generation was produced by coal, 32% by renewables, and 9% by natural gas; so, while coal is being phased out in many countries, it is still the major source to supply electricity demand growth. Coal emits 2.6 times more CO2 than natural gas for power generation, while natural gas provides at the same time energy security and flexibility, an essential feature for the development of intermittent renewable energy. Incentivizing a mix of natural gas and renewable energy to substitute coal is a low-hanging fruit to accelerate the transition; natural gas resources from Latin America and the Caribbean could contribute to supplying the gas needed for the global shift away from coal.

A very different situation exists regionally in Latin America and the Caribbean, where the power mix is dominated by hydropower, coal plays only a marginal role with 5% of the market share, and natural gas has many functions depending on the country considered (baseload, peak-shaving, flexibility, etc.). There is room for natural gas to replace coal for power generation in the region, mainly in Chile, where it represents around one-third of the share, but also in Central America and the Caribbean, where expensive, imported, and highly polluting fuel oil, diesel or coal play a central role. LNG-to-power projects have been successfully developed in the Dominican Republic, Panama, El Salvador, and Jamaica. In countries like Brazil, natural gas is crucial in providing flexibility to the power sector. This was evident during the last massive drought in 2021 when water reservoirs hit record lows, and LNG imports hit record highs. Natural gas is the dominant source of energy for power generation only in a few countries like Argentina, Bolivia, Trinidad & Tobago, and Mexico.

This paper shows how natural gas has helped to vastly reduce emissions in some countries. In brief, thinking about natural gas in the region's power sector implies understanding the specific role that natural gas plays in the particular context being considered.

Additionally, with a more medium-term focus, new combined-cycle gas turbine (CCGT) power plants can consume both natural gas and hydrogen, thus reinforcing the role of gaseous molecules in ensuring a reliable energy supply in case of renewables' intermittency.

Road transport is a priority sector for the region

In Latin America and the Caribbean, because of the region's geography and economic system, primarily based on the exports of natural resources located inland at great distances from the ports, the transport sector's share of CO_2 emissions is much higher than in other regions, around 40%, and reaching approximately 600 Mt of CO_2/per annum (OLADE Panorama Energético, 2022). The bulk of goods and people transportation (about 85% of tonne-km) is done by trucks and buses fueled by inefficient diesel engines.

Combusting natural gas produces 27% fewer CO_2 emissions than diesel fuel on an energy equivalent basis, so shifting to natural gas can bring quick wins and sustainable solutions where natural gas is abundant. This will avoid generating lock-ins or stranded assets in this very complex sector, where many technologies are just emerging (e.g., electric, hydrogen, etc.). At the same time, natural gas use is reducing substantially pollutants like SOx and NOx, thereby improving air quality in the cities and the region at large. There are many success stories detailed in the countries' insights, such as the Transmilenio bus system in Bogotá, or the relatively large-scale development of compressed natural gas (CNG) as a vehicle fuel in some countries such as Argentina, Bolivia, Brazil, Colombia, or Peru.

Maritime transport is another sector where many evident opportunities arise

International maritime transport is a relatively concentrated market, with a mandate for decarbonization established by the International Maritime Organization (IMO). LNG can reduce GHG emissions by more than 20% in bunker vessels in the short term with a mature and safe technology that can pave the way to net zero. The strategic position of the Panama Canal and increasing LNG infrastructure are two critical drivers for success. While not much progress has been made to date, a successful LNG shipping experience in the River Plate is highlighted in the document.

Decarbonizing natural gas is also a top priority

Natural gas companies are striving to reduce their carbon footprint by reducing flaring, venting, and boil-offs, as these represent new competitive advantages. While there is an overarching energy transition, the natural gas industry is actively pursuing options for improving its own transition to low-carbon gases. The main emerging alternative technologies are CCUS, biomethane, and hydrogen; there are opportunities for all of them in Latin America and the Caribbean. Some of them are highlighted in the document, particularly biomethane in Brazil or hydrogen, ammonia, and methanol production in Trinidad & Tobago.

Natural gas can contribute to decarbonize the agricultural sector in Latin America and the Caribbean

The complexity of the transition to low-carbon economies is also impacted by shifts in other key products and materials for economic prosperity. In the case of Latin America and the Caribbean, agriculture is a crucial activity, and it relies mainly on imported fertilizers. Industrializing natural gas, where abundant, represents another opportunity for development, which could add more value to the molecules and substitute imports. New technologies such as CCUS/blue hydrogen can help to reduce the carbon footprint of fertilizer production in the short term, by utilizing depleted fields. The main opportunities arise in countries with abundant natural gas reserves, some level of industrial development, and vast agricultural activity. This is very relevant for some countries such as Brazil, the leader in agricultural exports.

New poles of regional gas integration are naturally emerging

The dynamics of natural gas supply and consumption patterns have been changing in the region, opening new opportunities for mutually beneficial solutions through natural gas regional integration.

In the Southern Cone, where physical integration has existed since the 1990s, the development of Vaca Muerta, the opening of the natural gas market in Brazil prompting surges in demand, and the production dynamics in Bolivia, are changing the integration map of the sub-region; it combines with new possibilities to supply gas from Argentina to Brazil, directly via new pipelines, through LNG, or in an integrated solution including Bolivia as an infrastructure hub.

In the South Caribbean, Trinidad & Tobago's declining production and consequent underused gas industrialization and LNG export infrastructure capacity could leverage the development of neighbor Venezuela's non-associated offshore gas reserves. Discoveries offshore Colombia, Guyana, and Suriname could complement this picture. Mexico, which is developing infrastructure to export US shale gas through the Pacific Basin, can be considered another emerging pole and also has deepwater gas potential. Finally, LNG will also play a key role in regional gas integration and energy security, as it could provide the flexibility that pipelines cannot or where they are not feasible to be built, such as in the Caribbean islands.

In summary, natural gas is essential to the sustainable economic and social development of the Latin America and Caribbean region. It is also a mature technology, ready to contribute and provide quick wins that are consistent with long-term decarbonization objectives. Collaboration and pragmatism are the keys.

SECTION 1

Introduction and Rationale

Introduction

Climate change is one of the greatest, most urgent, and complex challenges of our time. According to the Sixth Assessment Report (AR6), issued by the Intergovernmental Panel on Climate Change (IPCC)[1], the average surface temperature has increased approximately 1°C since the 19th century. The same report states that this trend, mainly caused by the increasing concentration of GHGs in the Earth's atmosphere, is unequivocally caused by human activity.

The Paris Agreement[2], signed in 2015 during the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC), and adopted by almost all countries, is the cornerstone of climate action today. It established the goal of limiting global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels and defined several instruments for its implementation, such as the elaboration of Nationally Determined Contributions (NDCs) and Long-Term Climate Strategies (LTS), among others. Undoubtedly, collaboration between governments, international organizations, and the private sector are needed to achieve this massive goal. This is now even more important, following the World Meteorological Organization (WMO) report[3], which revised the possibility of reaching the 1.5°C threshold in the next five years down to 50%.

Energy is an essential input for any human activity, and for social and economic development. The use of coal first, and oil and natural gas later, generated a leapfrog in productivity, enhancing overall welfare levels and shaping the world as we know it today. However, around 73% of global GHG emissions are generated by energy use, particularly by burning fossil fuels. For this reason, decarbonization and tackling climate change imply a radical transformation in how we supply and use energy. To keep temperature rise within a range that averts the worst climate effects, all industrial sectors and end-users must transform their consumption patterns. However, this change in behaviors will be a real cornerstone in the achievement of climate goals in the coming years. This is particularly so, given that the concept of "hard-to-abate" sectors is extended today not only to those industrial sectors with technical challenges to overcome, but also to sectors where a socio-economic component is one of the main bottlenecks.

At the same time, the transition must be just, as large numbers of the world's inhabitants still do not have sufficient access to energy, which undermines their development opportunities; or their livelihoods rely mostly on the fossil fuels value chains.

The average surface temperature has risen approximately

1°C

since the 19th Century.

The probabilities to reach the 1,5°C threshold are

50:50

in the next five years.

GHG Emissions from Energy

73%[4]	43%
World	**LAC**

[1] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001.
[2] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[3] WMO, World Metrological Organization. Climate Update 2022-2026. Publication May 2022.
[4] Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-greenhouse-gas-emissions' [Online Resource]

The fulfilment of the 17 United Nations Sustainable Development Goals (SDGs), however, implies a holistic approach.

There are no one-size-fits-all solutions, as each country departs from a very different starting point in terms of energy supply, energy use, infrastructure, geography, resource endowments, economic and social situation. Therefore, all energy sources will have a role in the transition to low-carbon economies.

A comprehensive, rational, science-based approach is necessary to face the double challenge of decarbonizing the world economy while granting economic and social development to a growing population.

In this context, many opportunities arise for decarbonizing through natural gas and low carbon gases in Latin America and the Caribbean.

The region is vast, complex, and heterogeneous but, in general terms, is composed of middle-to-low-income countries with high levels of poverty and inequality, a relatively decarbonized power sector, a lower than average contribution to climate change, and a GHG emissions profile driven by the Agricultural, Forestry, and Other Land Use sectors (AFOLU), whose emissions are greater than those from energy use in many countries. Conversely, the region is endowed with vast and diverse natural resources, and the gas sector plays a key role, being the main source of exports, fiscal income or investment in some countries.

The following pages describe and explore opportunities for the region, including the development of domestic natural gas resources both for use in the country or for export to decarbonize other regions of the world; decarbonization of demand-side sectors such as transport, industry, or power generation; enhancing the deployment of renewable energy; fostering the development of innovative alternatives such as biogas, biomethane, or hydrogen; and introducing new value chains such as fertilizer production, among others. The paper also provides deep dives into some countries to illustrate the above-mentioned opportunities and their business cases. There are insights from Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Mexico, Peru, Suriname, Trinidad & Tobago, Venezuela, and the region of Central America and the Caribbean.

The International Gas Union (IGU), the Regional Association of Oil, Gas, and Renewable Energy Companies in Latin America and the Caribbean (ARPEL), and the Latin America Energy Organization (OLADE), are three organizations committed to decarbonization of the energy system.

IGU, as a body of the international gas industry; ARPEL, as a body of the Latin America and the Caribbean oil, gas, and energy industry; and OLADE, as an advisory organization to the governments of Latin America and the Caribbean, are working to enhance climate action in their areas of influence.

ARPEL, IGU, and OLADE partnered to develop this white paper, with the objective of establishing a common narrative about the role and opportunities for natural gas and low-carbon gases in Latin America and the Caribbean, aiming to contribute to international energy dialogue, and hence to the effective and just transition of the energy system in the region.

The paper was prepared in close collaboration with the national gas associations, and other key stakeholders in the region. The consultative process included a First Stakeholder Dialogue[5] held in Rio de Janeiro in September 2022, meetings and interviews, and a peer-review carried out in February 2023.

[5] Stakeholder's Dialogue. The Social and Economic Value Creation of Gas Molecules in The Energy Transition.
21.9.22 Joint Statement ARPEL, OLADE, IGU, CAF-Banco de Desarrollo de America Latina, with the support of IBP.

Rationale

This joint initiative tries to provide a snapshot of the complexity of decarbonization, with the necessity of balancing energy transition, affordability, and security — the ***Energy Trilemma*** — but with an understanding that it is not only restricted to energy as natural gas and low-carbon gases are also feedstock for chemicals, fertilizers, and synthetic fuels in the short term. Our hope is that this paper offers a broad perspective to the different stakeholders and inspires the journey to a circular economy, contextualizing the relevance of gas molecules in the prosperity of nations, supporting the commitments of the UN goals, and highlighting the role of natural gas and low-carbon gases as cornerstones of climate change mitigation. The chart below offers an overview of the rationale that has led the paper's preparation.

Driving Forces

- Decarbonization and alignment with the Paris Agreement
- Socio-economic development (leaving no-one behind and maintaining uninterruptible the energy demand)
- Just transition and affordability
- Technological neutrality
- Costs and early stages technologies
- Financing mechanisms
- Energy and food security in line with population growth
- Seeking to build a bridge between today and future generations

Complexity

- Energy transitions are essentially social, economic, and technical processes
- Diverse pathways for decarbonization for different geographies and starting points
- Overall value chain approach to include technology, infrastructure, regulations, players, and energy services; including "hard-to-abate" or "hard-to-electrify" sectors
- A cost-benefit approach

Pragmatism

- Effectiveness: Results matter, all technologies and sources of energy have a role to play in the transition (also the ones still to be developed)
- Collaboration: Natural gas can accelerate the transition while enabling the deployment of other low-carbon sources (bio-methane, hydrogen, e-gases)
- Timing is critical: natural gas and green gases can mitigate emissions today with proven and mature technology
- Consistency: short-term delivery and long-term goals
- Flexibility: no "bans" approach to amplify options to succeed

The value of Environmental, Social & Governance (ESG) Good Practices

- Industry must do its best efforts to reduce GHG emissions in its own value chain (efficiency, flaring, venting, boil-offs, etc.)
- Emissions are crucial, as sustainability and governance are for the overall value chain
- Stakeholder alignment, to create value for society
- Positive and continuous dialogue between industry, finance, and policymakers, built on transparency, compliance and reporting

SECTION 2

Natural Gas Scenarios

Introduction

Understanding the opportunities for natural gas in Latin America and the Caribbean in the energy transition implies looking into the future. While climate change and policy action are the governing forces of the transition to low-carbon economies, little can be said about what the process will be. Perhaps the only certain thing about the future of energy is that it is deeply uncertain.

However, based on the analysis of the scenarios and prospective documents published by the most reputable international organizations working in the energy sector, this chapter identifies key trends and conclusions for natural gas about which there is a high level of agreement.

The second part of the chapter gives an insight into Latin America and the Caribbean, based on the OLADE scenarios.

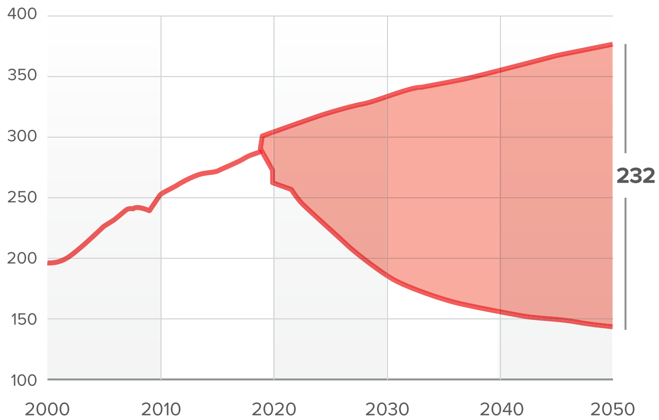
Trends about natural gas in modeling scenarios

1. Energy demand is most likely to grow steadily until 2050

Most scenarios forecast energy demand growth in the next three decades. Driven by population growth and economic development, energy demand growth will put additional pressure on the energy supply and the minerals/metals value chain. How this gap will be filled is not a trivial question regarding emissions and the pathways for decarbonization.

Total Primary Energy Demand Scenarios Through 2050 (Million boe/d)

Source: IEF
Scenarios Considered: IEA, WEO 2022. OPEC WOO 2022, IRENA World Energy Transitions Outlook 2022, BP Energy Outlook 2022, GECF 2022 Global Gas Outloon to 2050, Equinor Energy Perspectives 2022, BNEF New Energy Outlook 2022, IEEJ Outlook 2023, IPCC Climate Change 2022: Migration of Climate Change.

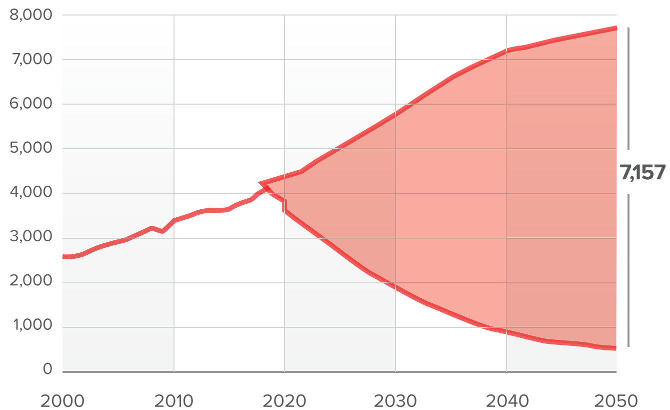


2. There is a high level of uncertainty for natural gas

There is no alignment about the future global demand for natural gas. The range between the high and low scenarios is 7,157 Bcm, about 80% larger than today's natural gas market. Uncertainty lies mainly in how climate policies, alternative technologies, and low-carbon gases will unfold in the short-to-medium term. However, most of the scenarios under a "forecast approach" expect demand for natural gas to increase from the current level; while scenarios expecting a sharp decrease are based on a "backcast approach".

Natural Gas Demand Scenarios Through 2050 (bcm)

Source: IEF
Scenarios Considered: IEA, WEO 2022. OPEC WOO 2022, IRENA World Energy Transitions Outlook 2022, BP Energy Outlook 2022, GECF 2022 Global Gas Outloon to 2050, Equinor Energy Perspectives 2022, BNEF New Energy Outlook 2022, IEEJ Outlook 2023, IPCC Climate Change 2022: Migration of Climate Change.



3. Natural gas demand growth is expected to come from the emerging world

Demand is expected to increase in emerging economies, driven by economic and population growth, while the developed world transitions to low-carbon energy, including biomethane and other gases.

4. LNG trade and infrastructure are expected to grow, adding flexibility and security to energy supply

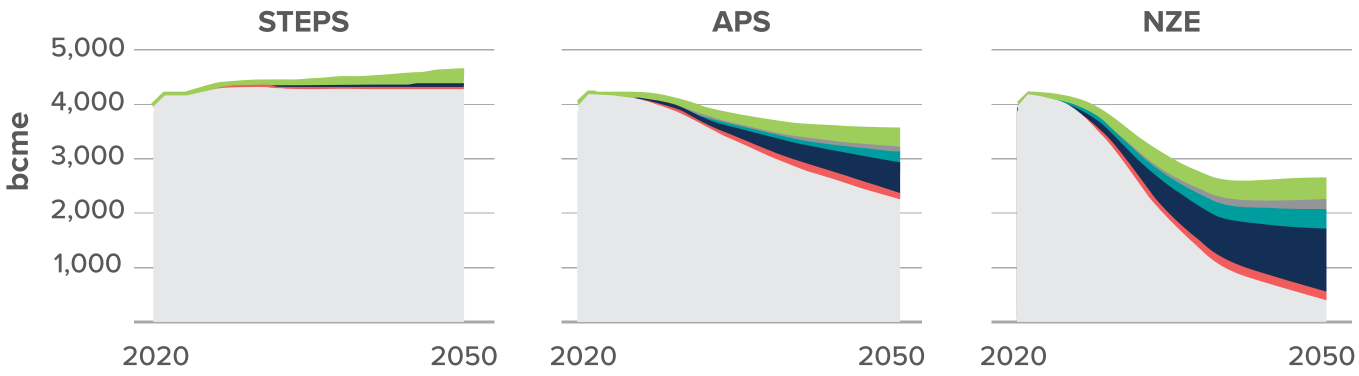
LNG trade has been growing steadily in the last decade. In 2012, there were 93 LNG regasification terminals in 26 countries with a total regasification capacity of 668 Mtpa; the volume traded was 236.3 Mt (Source: GIIGNL). In 2022, importing markets increased by 18, reaching 44 in total. Regasification capacity grew by 49%, reaching 993 Mtpa, and the total traded volume was 372.3 Mt, representing an increase of 58%. This trend is expected to continue in the future, based on announced projects and the views of the different scenarios, some of them, already in progress, such as Vietnam and Philippines, the new LNG import countries in 2023. As the LNG market matures and becomes more liquid, it becomes more attractive as a source of flexibility and energy security, especially when floating, regasification, and storage units (FSRUs) are deployed. Growing infrastructure will also open new opportunities, such as decarbonizing maritime transport.

5. The natural gas sector needs to make its own transition

No matter what the future looks like, natural gas sector needs to make its own transition, through carbon-offsetting, CCUS, incorporating low-carbon gases to the portfolios, among others. Most of these technologies are relatively mature, being “non-regret” investment options that need to be developed.

Natural Gas in IEA’s World Energy Outlook 2022 Scenarios

Source: IEA WEO 2022



NATURAL GAS: UNABATED, WITH CCUS

LOW-EMISSIONS HYDROGEN (BY SOURCE): ELECTROLYSIS AND BIOENERGY, LOSSES FROM H_2 CONVERSION, FOSSIL FUELS WITH CCUS, BIOGASES

Stated Policies Scenario (STEPS)
Announced Pledges Scenario (APS)
Net Zero Emissions by 2050 (NZE)

6. Windows of opportunity will not always be open

Demand for natural gas is expected to be more competitive in the future, given other low-carbon gas alternatives. Thus, taking advantage of the windows of opportunity that are now open implies being proactive in creating the conditions for the investments needed in E&P, infrastructure, and market legislation that offer stable conditions for the energy and financial sector.

7. Timing and the pathways of transition are crucial, but scenarios say little about this

Energy demand is expected to grow in the decades to come, opening a gap in energy supply that must be filled with different energy sources. Renewable energy solutions are not yet mature enough to fill this gap for many reasons (e.g., technology, infrastructure, supply chain, etc.) and will not be ready to scale up at the pace needed; part of this gap will be necessarily covered with fossil fuels.

Accepting this fact would lead to more balanced and effective transition pathways, as putting too much pressure on an unrealistic path could lead to bottlenecks that ultimately favor more carbon-intensive alternatives, thus delaying the transition. In other words, imposing restrictions on natural gas, the cleaner and more flexible of fossil fuels, may result in favoring coal and other worst alternatives regarding GHG emissions and environmental impacts.

8. Natural gas in Latin America and the Caribbean

Despite the accelerated penetration of alternative and renewable energy sources by virtue of a policy of deep decarbonization of the energy sector, it is expected that natural gas will continue to be one of the most important sources of energy supply in Latin America and the Caribbean.

The largest economies in the region, such as Brazil, Mexico, Argentina, and Colombia, show no signs of dispensing with the use of natural gas in their energy systems. According to OLADE, natural gas share in the Latin America and the Caribbean total primary energy supply would be between 21% and 30% in 2050, depending on the scenario considered.

The versatility of natural gas for use in different sectors and energy systems, its low cost in the region, abundance of regional resources, and relatively low carbon emissions, guarantee its role in the regional energy matrix in the medium and long term.

Other key conclusions

- **The transition is not only about the end point but also about how to reach that point.** Comprehensive energy planning is needed to find robust transition pathways.
- **Scenario techniques used for energy planning should be stress-tested to be more informative about the potential bottlenecks and their impacts on transition pathways, helping to avoid unintended consequences.** The special situation with metals and minerals, more concentrated in several locations, constraints for the finance of greenfield and brownfield projects, the quality decline of some minerals reservoirs, as well as the role of the power sector (the mineral sector is a high electricity consumer), should be considered, to maximize and design the decarbonization through decarbonized materials. An orderly transition is also related to the more effective measures to reduce the CO_2 emissions.
- **Natural gas and hydrogen** scenarios include the production of fertilizers and synthetic fuels. Today, half of global fertilizer production is underpinned by natural gas, utilized as feedstock to produce hydrogen. Given the expected increase in global population of 2 billion in the coming years, demand for both energy and affordable food will increase as well. Additionally, synthetic fuels and biofuels could be good alternatives in the mid and long term.
- As emissions from the **transport sector** surpass those from power generation in some countries, and it is the fastest-growing source of global emissions, **stress-tested scenarios** should analyze the alternatives of bio-fuels, synthetic fuels, and natural gas jointly with electric vehicles. Due to the atomization of the transport sector with a huge number of private vehicles, its decarbonization is particularly challenging, and it is directly related to GDP per capita.
- Up to now, **all the scenarios show continuing coal consumption by the end of the period.** As burning coal emits more than double the CO_2 compared with natural gas, **stress-tested** scenarios should minimize coal consumption with the support of natural gas to anchor renewable capacity deployment.

Natural Gas prospective in Latin America and the Caribbean

Introduction

Each year OLADE publishes the Energy Panorama of Latin America and the Caribbean, which, in addition to the statistics of the regions energy sector, includes a prospective chapter, where long-term energy scenarios for the region are presented. In the last edition of this publication (2022), two scenarios were analyzed for the period 2020-2050:

- A reference scenario or baseline (BAU) where the evolution of the regions energy sector is projected based on historical trend patterns and expansion plans published by OLADE Member Countries, and;
- A prospective scenario (PRO NET 0) where a deep decarbonization policy of the energy sector is simulated, in order to contribute to climate change mitigation strategies and achieve the long-awaited global goal of zero net CO_2 emissions by 2050.

It is worth mentioning that due to the abundant availability of the natural gas resource in the region, its competitive price, and its lower carbon emission factor compared to other fossil fuels, both in the BAU scenario and in the PRO NET 0 scenario, natural gas plays a fundamental role in the regional energy supply, being considered in many countries as a means of transition towards a low-carbon economy.

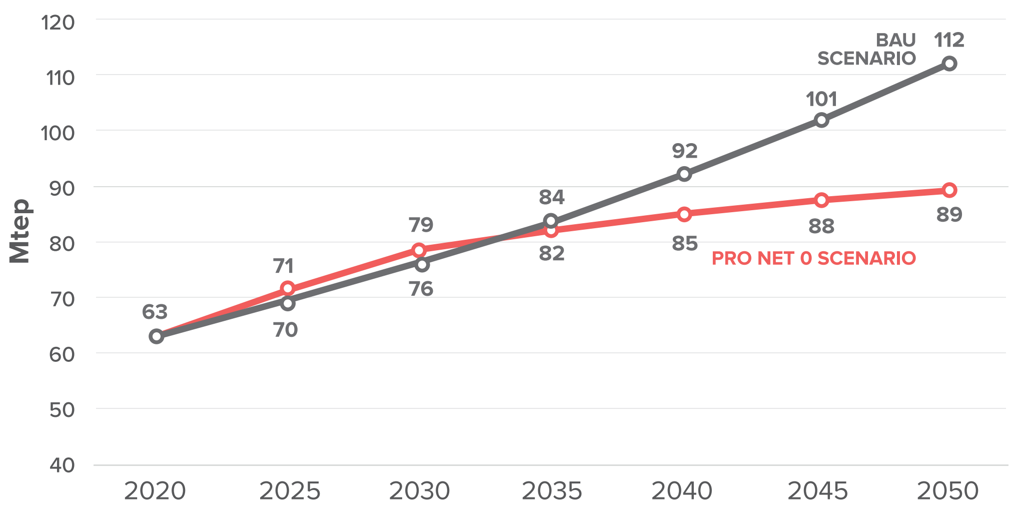
With this background, the results of the prospective use of natural gas in the Latin America and the Caribbean are presented below.

Prospective consumption of natural gas

According to the expansion plans published by the countries of the region and their historical evolution, for the BAU reference scenario, the consumption of natural gas in the region would almost double in 2050, compared to the base year (2020). In the PRO NET 0 scenario, although consumption would have a more accelerated growth until 2030, from that year this growth slows down, reaching 2050 with a value only 40% higher than that of the base year and 20% lower than projected in the BAU scenario.

Projection of total final consumption of natural gas in Latin America and the Caribbean, by scenario

Source: Energy Panorama of Latin America and the Caribbean, OLADE, 2022



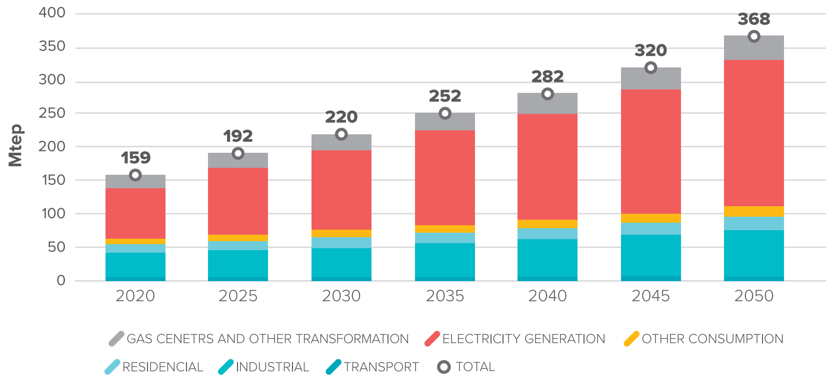
Projection of domestic demand for natural gas in the region by subsectors

BAU scenario

The sub-sectors that predominate in the internal demand for natural gas in the region are electricity generation and industry. Under the premises of the reference scenario (BAU), the total domestic demand for natural gas would increase by 132% compared to the base year during the projection period, with the demand for electricity generation having the greatest increase with 190%.

Projection of domestic demand for natural gas in Latin America and the Caribbean, BAU scenario

Source: Energy Panorama of Latin America and the Caribbean, OLADE, 2022

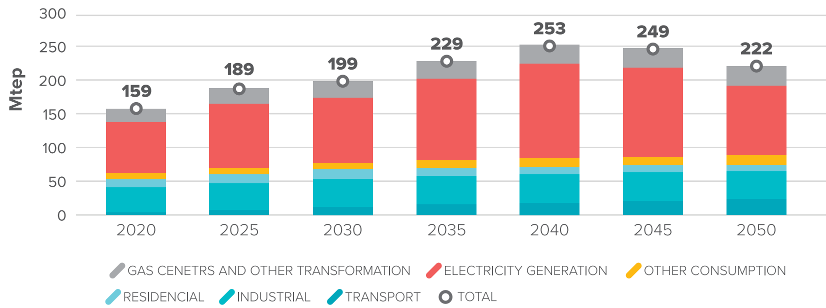


PRO NET 0 scenario

Even under the hypothesis of a profound decarbonization of the energy sector (PRO NET 0), growth in domestic demand for natural gas would continue until 2040, driven mainly by electricity generation. That year it would begin to decrease, reaching 2050, with a value 40% higher than that of the base year, but 40% lower than that projected in the BAU scenario. It is also worth noting the increase in the consumption of natural gas in the transport sector, which by 2050 is more than triple that projected in the BAU scenario, for the same year.

Projection of domestic demand for natural gas in Latin America and the Caribbean, PRO NET 0 scenario

Source: Energy Panorama of Latin America and the Caribbean, OLADE, 2022



Projection of electricity generation from natural gas

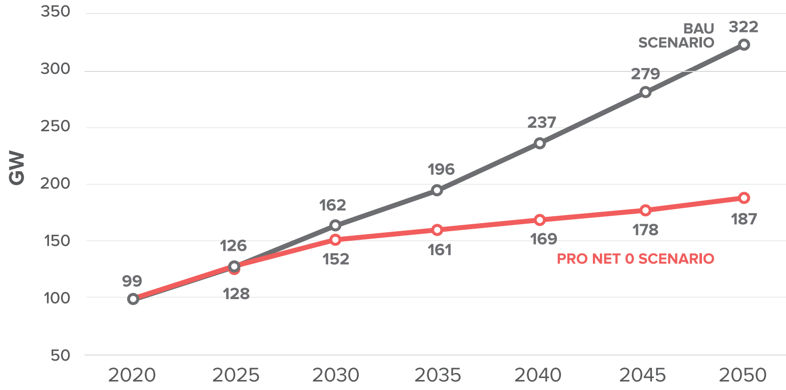
Power generation capacity

Many of the countries in Latin America and the Caribbean contemplate the installation of new natural gas power plants in their expansion plans, displacing the use of coal or liquid fossil fuels as firm energy back-up for their generation systems, with an increasing component of non-manageable renewable energies such as wind and solar.

In this context, in both scenarios the expansion of the natural gas power generation capacity is maintained, with the difference that while in the BAU scenario the capacity of these plants triples by 2050, in the PRO NET 0 scenario it only increases 87% compared to the base year.

Projection of natural gas-fired power generation capacity in Latin America and the Caribbean

Source: Energy Panorama of Latin America and the Caribbean, OLADE, 2022

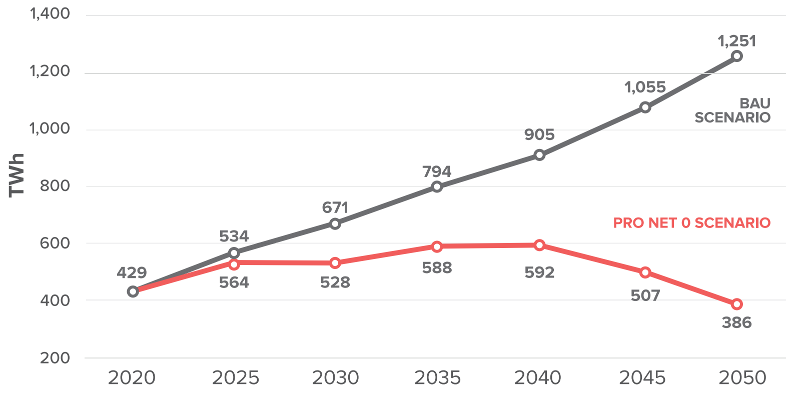


Electricity generation

Regarding electricity generation, while in the BAU scenario natural gas plants practically triple their energy production in the projection period, in the PRO NET 0 scenario this production shows a moderate net increase until 2040, when it begins to decrease. By 2050, production falls 10% compared to the base year and is 70% less than what is projected in the BAU scenario for the same year. This decrease is due to the greater penetration of technologies with renewable sources, which have a higher priority in energy dispatch.

Projection of electricity generation with natural gas in LAC

Source: Energy Panorama of Latin America and the Caribbean, OLADE, 2022

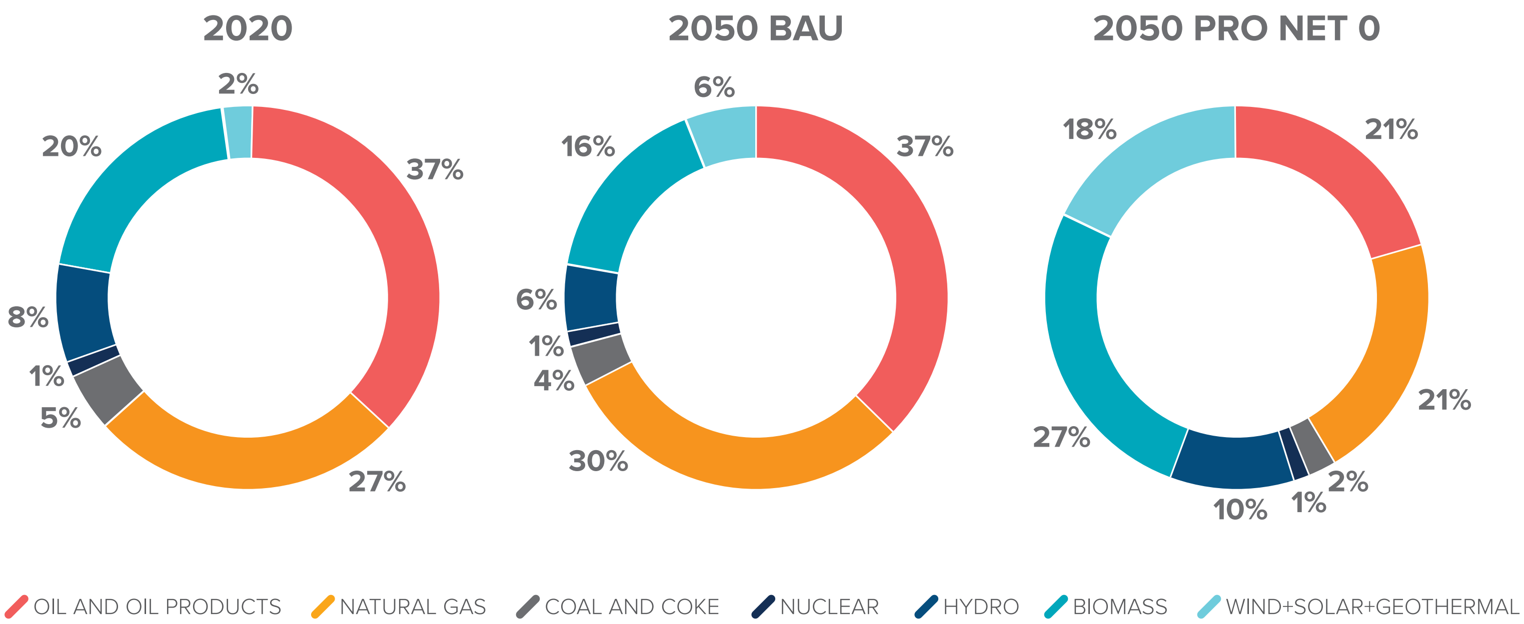


Projection of the participation of natural gas in the total energy supply matrix of Latin America and the Caribbean

Regarding the participation of natural gas in the region´s total energy supply matrix, while in the BAU scenario this source remains in second place in importance behind oil and oil products, with around 30% participation, in the PRO NET 0 scenario it falls to third place with a 21% share.

Projection of the total energy supply matrix in Latin America and the Caribbean

Source: Energy Panorama of Latin America and the Caribbean, OLADE, 2022



SECTION 3

Latin America and the Caribbean Overview

SECTION 3

Latin America and the Caribbean Overview

Socio-Ecomomic Overview

Latin America and the Caribbean is a vast and heterogeneous region. With an area of over 20 million km^2 and a population exceeding 650 million inhabitants, it is a region of diverse geographies and climate systems; including the world's largest rainforest, the most extensive mountain range, and the driest desert. Around 80% of the population lives in cities, mainly concentrated in the capitals and some large urban areas. Its average population density is around 31 people per km^2, highly concentrated in urban areas and less concentrated in rural ones. This fact is an important obstacle for infrastructure development and a challenge for livability in built-up areas.

In terms of socio-economic indicators there are also very diverse realities. Some 75% of the region's countries are in the low-income range, with significant levels of poverty and inequality, affecting the potential to have access to goods and services. The region's GINI coefficient, with a single average of 0.452[1] has followed a deterioration path. Regional female labor participation is still inferior to male participation (51.8% vs 74.5% respectively[2]). The unemployment rates[3] estimations for 2021 range from 11.6% for women to 7.8% for men. The consecutive Covid-19 and energy-food crises have resulted in Latin America and the Caribbean becoming one of the most affected regions economically. This has particularly impacted female labor participation, which has regressed to rates last seen two decades ago, increasing the gender gap even more. Fiscal deficit and access to capital are challenging, as recurrent macroeconomic problems affect the financial cost of projects and ease of doing business.

Latin America is a natural resource-rich region, and many countries are highly dependent on their extractive industries in terms of exports, investment, government income, and GDP. In fact, almost all countries in South America are oil and gas producers, in addition to those in Central America and the Caribbean. Natural gas is a key industry in countries such as Trinidad & Tobago, Bolivia, and Peru (the exporting countries of the region), but it plays an important role in other countries too. Mining is also a critical activity, being the most important industry in Peru and Chile, for example. The region is also rich in agricultural land and forests, supporting two important sectors of the economy; and there is a vast renewable energy potential still to be developed.

The growth pressure of the region's population in the last decades, together with an expected aging before mid-century brings new policy challenges, mainly for pension system coverage, and health systems. To begin to address these social challenges it is essential to reinforce and improve growth of the regional economy, which has been stagnant in the last few decades, reducing the gap with the most developed countries and restructuring the balance of payments. Compared to other continents, Latin America and the Caribbean's power system is the most decarbonized; which could foster a new reindustrialization, in an international context that rewards the best carbon footprint of any business. Additionally, the region's natural gas and critical mineral resources, as exports, have the potential to decarbonize other regions, not forgetting the relevance of fertilizer production, in a world where an additional 2 billion people are expected to demand more food and energy by mid-century.

Population

According to the United Nations Report 2022, "The Sustainable Development Goals Report", rising inflation and the impacts of the Ukraine-Russia conflict have resulted in an increase in the projection of people living in extreme poverty in 2022, from 581 million in the previous forecast to between 657-676 million. This equals 1 in 10 people worldwide suffering from hunger. The UN SDGs are focused on reducing inequality among countries and ensuring access to affordable, reliable, sustainable, and modern energy for all.

Global population growth is a key indicator when predicting growth in energy access. With an increase of 80% in the last 40 years, driven by the growth in Asia, Africa, and Latin America and the Caribbean, the world's population has nearly doubled from 4.4 billion people to 8 billion in 2022. The revised calculation published by the UN estimates reaching 9 billion people in 15 years and 10 billion by 2058.

With a current estimated population of 662 million people, the Latin America and Caribbean region represents 8.2% of the global population, with projections of 752 million people by 2060. Furthermore, a deeper analysis by ECLAC emphasizes a change in the demographic pyramid, with a move towards an aging population, and the subsequent new challenges[4] it entails.

[1] ECLAC, Social Panorama of Latin America and the Caribbean 2022. https://repositorio.cepal.org/bitstream/handle/11362/48519/1/S2200946_en.pdf (page 25).
[2] International Labour Organization, 2022, "Labour Overview Latin America and the Caribbean".
[3] Idem 1
[4] Latin American and Caribbean Demographic Centre (CELADE), the Population Division of ECLAC, United Nations 2022.

World

8 billion people

Projection
10 billion people (by 2060)

Extreme poverty
8.2% population

Latin America and the Caribbean

662 million people (8.2%)

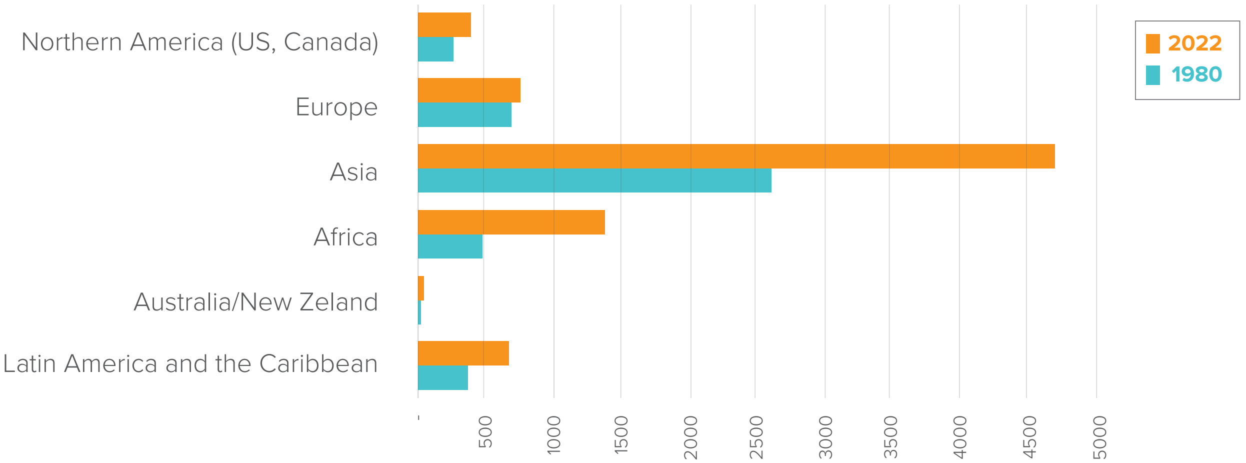
Projection
752 million people (by 2060)

Poverty
32% population

Extreme poverty
13% population

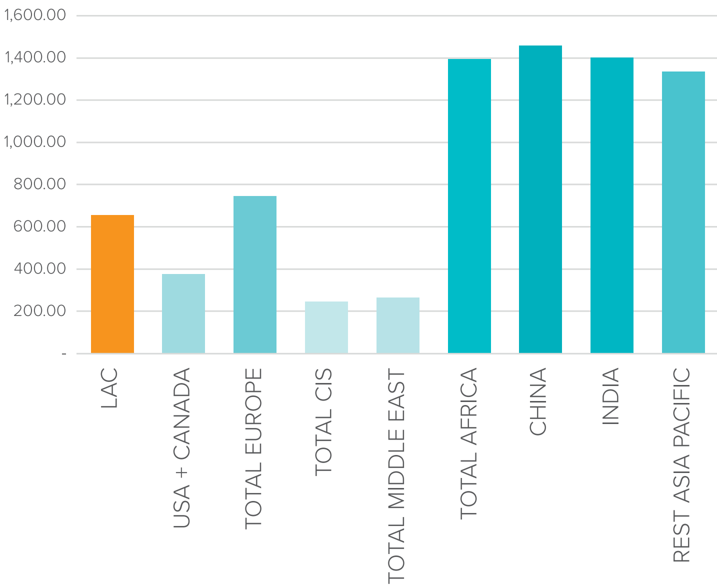
Population growth
(2022 vs 1980)

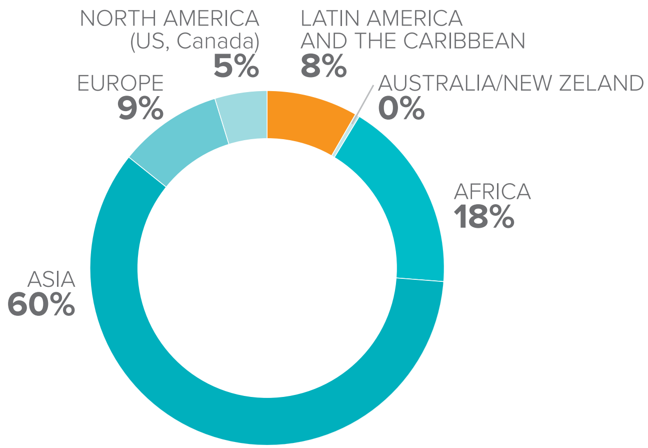
Data Source:
World Population Prospects,
United Nations 2022



Population
(Million inhabitants)

Data Source:
World Population Prospects,
United Nations 2022





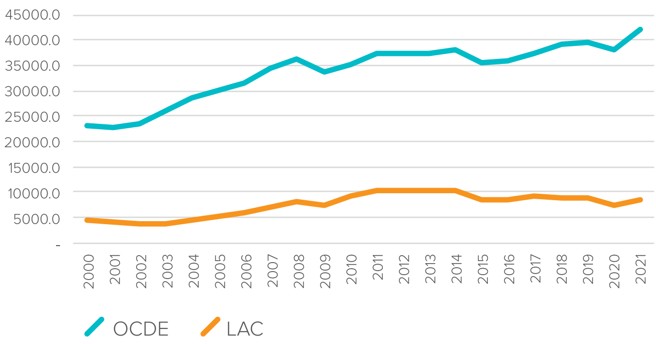
Economic indicators

From an economic perspective, Latin America and the Caribbean is formed by developing and under-developed nations, with among the lowest GDP per capita in the world, a key indicator to comprehend the overall wellbeing of the population, as well as its position relative to other economies. Inter-country comparison shows that GDP per capita in Latin America and the Caribbean is significantly below the OECD[6] average.

With an average of US$8,340 per capita, it is worth mentioning the extreme poverty that exists in Guatemala, Suriname, Jamaica, Belize, El Salvador, Bolivia, Honduras, Nicaragua, and Haiti, with a GDP of less than US$5,000 per capita.

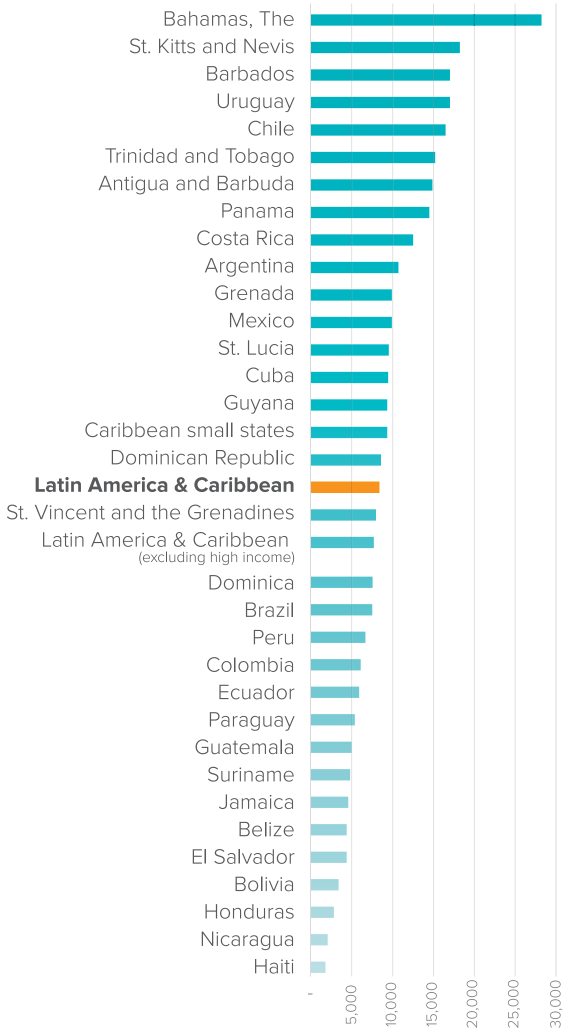
GDP/per capita LAC
(Current US$)

Data Source: World Bank (WDI Database)



GDP/per capita LAC
(Current US$)

Data Source: World Bank (WDI Database)



Furthermore, as a consequence of the international situation, the GDP growth of Latin America and the Caribbean is slowing down, with limited scope for monetary and fiscal policies in a complex environment. It is worth noting that as OECD observes in its Latin America Economy Outlook 2022, GDP per capita growth has stagnated in the region since 1980, not only hindering its convergence with more advanced economies, but also not following the growth trend of the emerging markets in Asia.

These differences of behavior in the economy, between Latin America and the Caribbean and Asia were highlighted in 2022 by ECLAC as structural, *"public investment in Latin America and the Caribbean is lower than in other regions of the world in both absolute and relative terms. On average, general government gross fixed capital formation in the region has been significantly lower than that recorded in emerging and developing Asian economies in recent decades, a period over which Asian countries have built dynamic and diversified economies"*

[6] OECD: Organisation for Economic Co-operation and Development

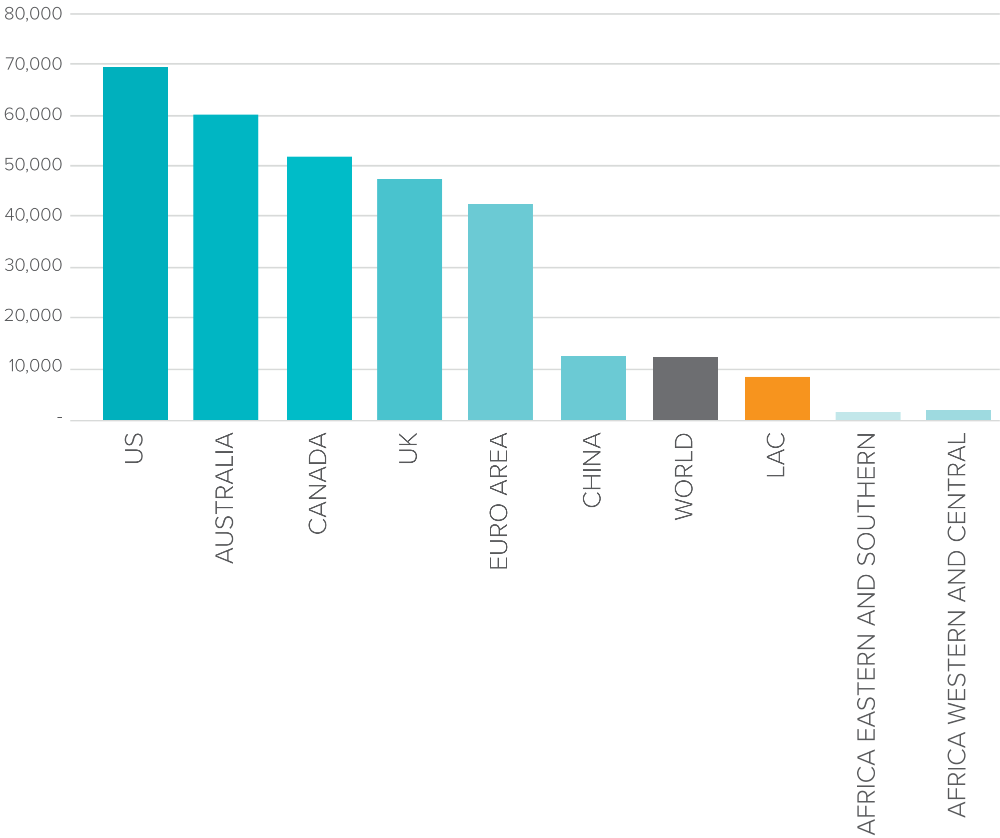
GDP LAC:

5,400 current billion US$

(Equivalent to 24% of the main economy USA, 23,300 current billion US$)

GDP/per capita
(current US$)

Data Source: World Bank (WDI Database)



Poverty and income distribution

Source: CEPALSTAT

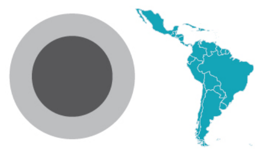
GINI COEFFICIENT

- 0.378 - 0.418
- 0.418 - 0.459
- 0.459 - 0.499
- 0.499 - 0.539

POPULATION LIVING IN POVERTY AND EXTREME POVERTY

- POPULATION LIVING IN POVERTY
- POPULATION LIVING IN EXTREME POVERTY

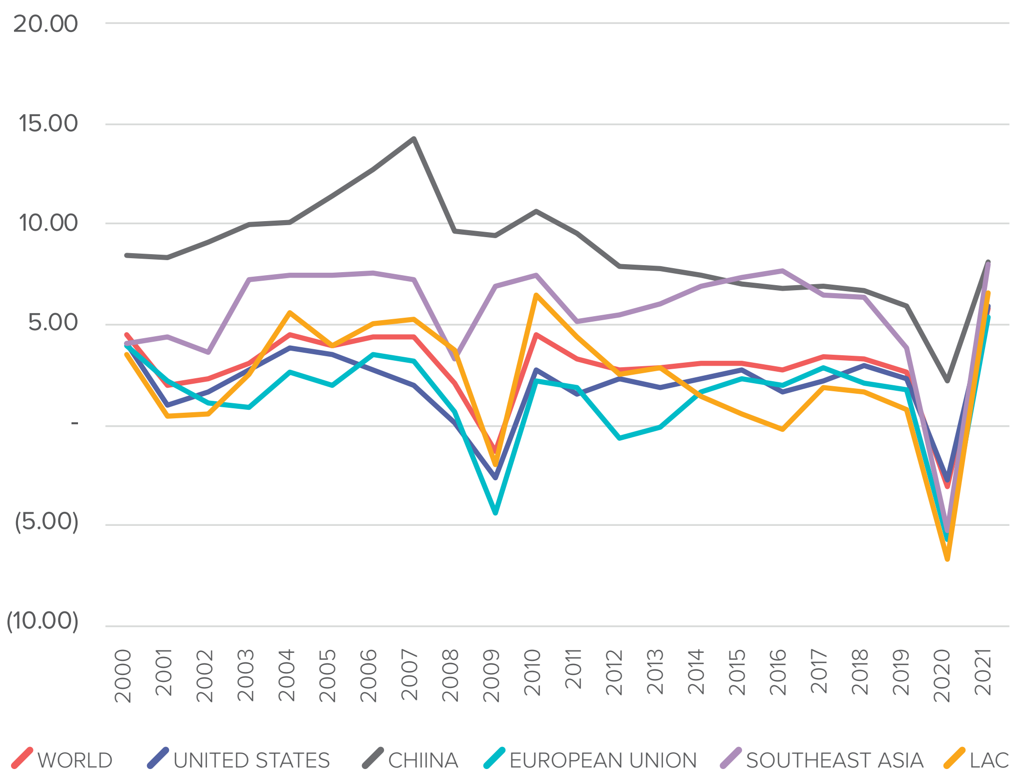
LATIN AMERICAN



33.0 g / 13.1 g 0.464 h

GDP growth (%)
Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars

Data Source: World Bank (WDI Database)

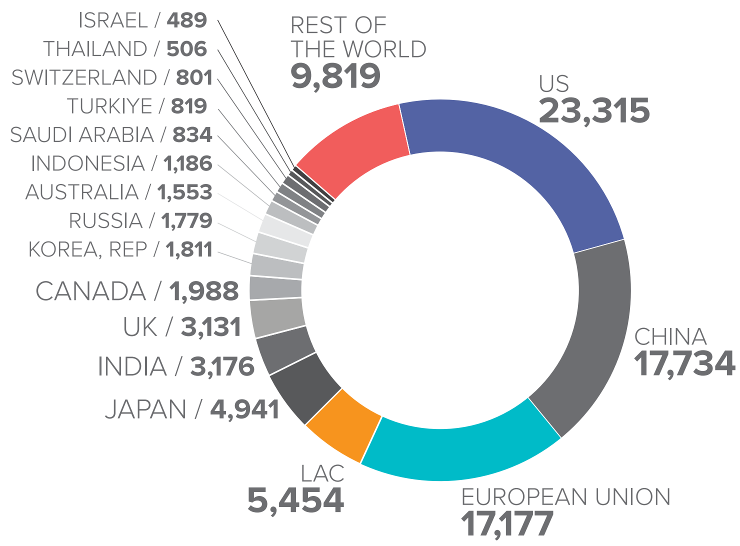


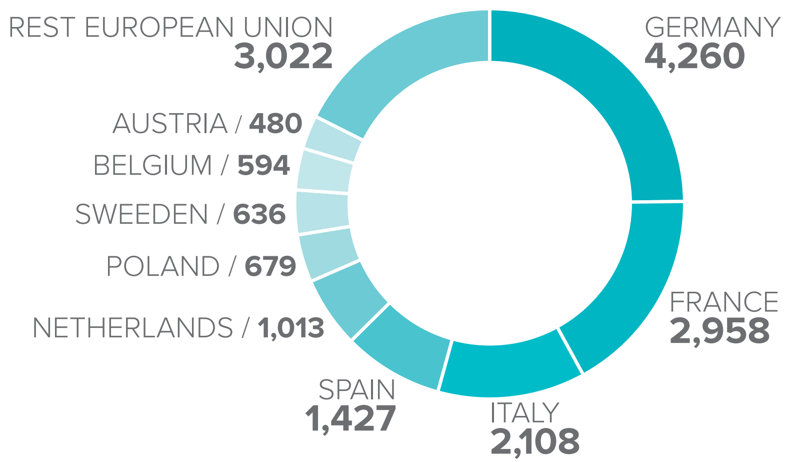
GDP growth in Latin America and Caribbean has followed a trend below that of the biggest economies, leading to an impoverishment of the region, which has been exacerbated in the last decade, while the economies of Southeast Asia and China have kept up their bullish momentum.

In absolute terms, GDP in Latin America and the Caribbean is three times lower than the European GDP, with a similar population.

World GDP
(billion current US$)

Data Source: World Bank (WDI Database)



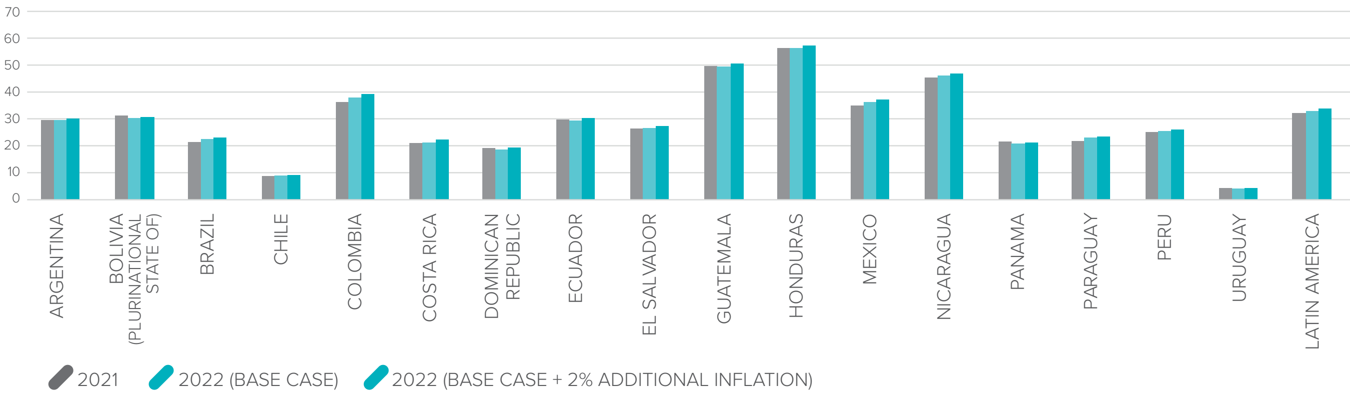


LAC
(GDP Billion current US$)

Data Source:
World Bank (WDI Database)

LAC
(projection of 17 countries) poverty (%)

Source: CEPAL (ECLAC) 2022



As mentioned by the American University of Washington DC, in its paper, “Innovation, Inclusion, and Institutions: East Asian Lessons for Latin America?”[7] sustained economic growth in the Asian countries taken as examples has led to a reduction in poverty and inequality, and job creation has allowed for the funding of social welfare expenditures. **The situation in Latin America and the Caribbean is one of stagnation, neither economic growth nor productivity has increased to enable the region to modify its status, and the gap with the most developed economies is increasing.**

Looking at the extreme poverty threshold of US$1.9 per day and the ambition of SDG target 1.1, by 2030, all countries, regions, and groups within countries, should achieve zero poverty with regard to this international poverty line. As of today, Latin America and the Caribbean starts from a worse base case. Poverty levels are translated automatically into less access to services like education, electricity, healthcare, sanitation, inter alia, and making the societies more vulnerable to migration movements, climate change, and conflicts.

United Nations:
Poverty entails more than the lack of income and productive resources to ensure sustainable livelihoods. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination, and exclusion, as well as the lack of participation in decision-making.

Ending poverty in all its forms is the first of the 17 Sustainable Development Goals (SDGs) of the **2030 Agenda for Sustainable Development.**

[7] Industrial Upgrading and Innovation Capability for Inclusive Growth: Lessons from East Asia.

In its June 2022 report[8] "Repercussions in Latin America and the Caribbean of the War in Ukraine", ECLAC reports on its expectations of poverty levels in 2022 reaching 33%, compared to 27.8% in 2014, and a doubling of extreme poverty from 7.8% in 2014 to 14.9% in 2022, whereas extreme poverty average in the rest of the world is 9%. Similar figures are mentioned in the OECD outlook 2022.

The current climate, energy, and food crisis has driven economic deceleration and recession. Moreover, inflation has exacerbated the region's vulnerabilities, resulting in the need for extraordinary policy measures, with the consequent increase in interest rates in the region. As highlighted by IMF, high inflation is a bigger challenge in smaller economies because they are less diversified, rely more on imports, and have more limited policy levers at their disposal. Many of the small countries of the region have high public debt and elevated sovereign spreads.

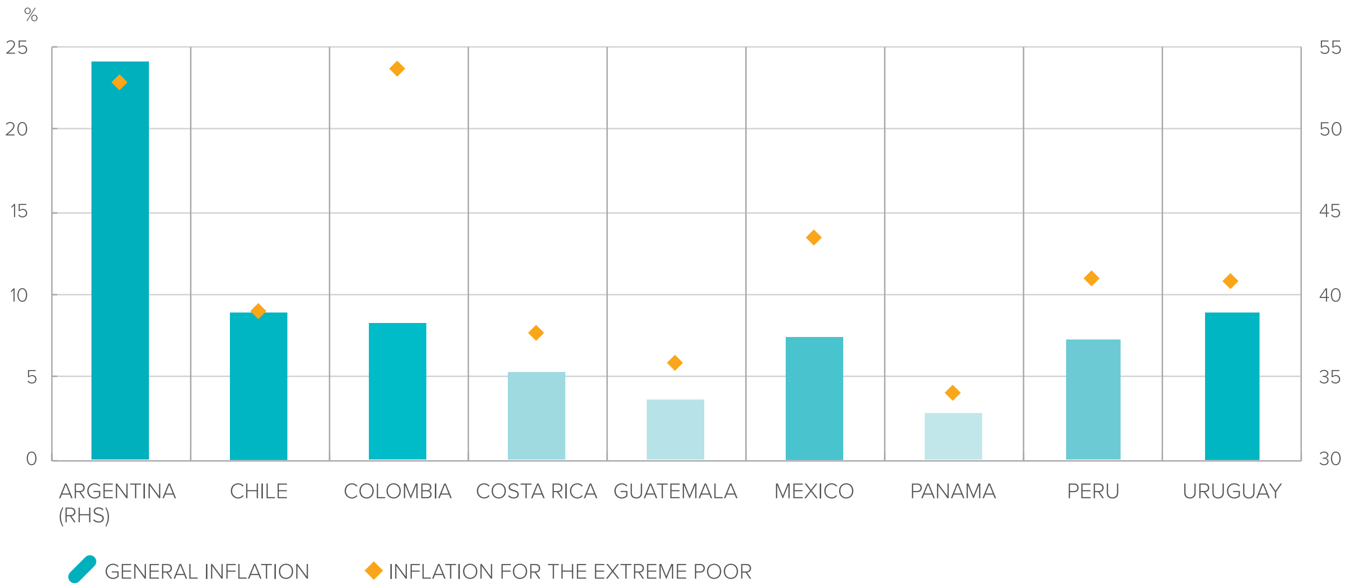
In the same June 2022 report, ECLAC remarks, "in 2023 Latin American and Caribbean countries will have to face an unfavorable international context once again, with forecasts for a deceleration in both global growth and trade, higher interest rates, and less global liquidity.

"In South America, some countries are particularly affected by the low dynamism of China, which is an important market for their goods exports. This is the case, for example, of Chile, Brazil, Peru, and Uruguay, which ship more than 30% of their merchandise exports to China (40% for Chile). South America will also be impacted by the decline in commodities prices and by restrictions on the space that public policy has to bolster activity. High inflation has affected real income and the effects on private consumption have already been observed in some countries as of the second half of this year."

The impact of inflation has different effects on overall population and the extreme poverty groups, as can be observed in the analysis made by OECD, where many countries in Latin America and the Caribbean face an inflation rate of around 10%, while their poorest communities are impacted at an equivalent rate of around 40%, due mainly to the increase in food prices.

Inflation in selected Latin American countries
(%)

Source: OECD



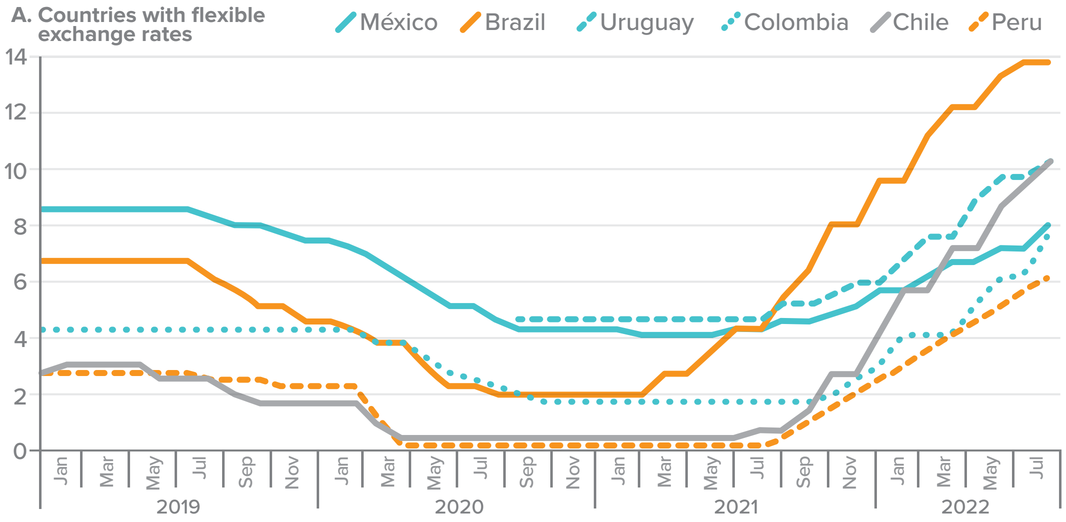
And although IMF recognizes the effort made through the monetary policies of the region's governments in the last few decades, (in the early 1990s, inflation exceeded 40% in one-fourth of all LICs, and presently it has changed to single-digit inflation), the current crisis has provoked a new regression to high inflation rates. "In recent years, most low-income countries (LICs) have been remarkably successful in reducing inflation to single-digit levels, and many LICS are engaged in reforms to make their monetary policy frameworks more systematic, transparent, and forward-looking, often with technical support from the International Monetary Fund (IMF)".

A good example of this more systematic approach was seen at the beginning of 2021, when central banks in Latin America and the Caribbean implemented new policies to counter the growth of inflation, even earlier than the European Central Bank.

[8] Repercussions in Latin America and the Caribbean of the war in Ukraine: how should the region face this new crisis, ECLAC, 2022.
[9] IMF, 2022, "Do Monetary Policy Frameworks Matter in Low-Income Countries?".

Latin America and the Caribbean (selected countries): monetary policy interest rate. Jaunary 2019-July 2022
(Percentages)

Source: ECLAC



Main outstanding priorities to foster socio-economic growth in Latin America and the Caribbean

The challenge to transform the region's economies is huge, where economic growth is a main priority, improving productivity, attracting new investments in all the sectors, leveraging on the good conditions in terms of resources and the decarbonized energy matrix. This can drive the improvement of social conditions and indirectly stimulates the decarbonization of sectors like transport, which is totally correlated to the GDP per capita.
Under this macroeconomic perspective, energy plays a crucial role in achieving a sustainable growth, which is more inclusive, and reducing inequalities, giving Latin America and the Caribbean the best opportunity to reach the advanced economies and at the same time help other economies that need to be decarbonized urgently.

Latin America and the Caribbean (countries that use the interest rate as the main monetary policy tool): variation in monetary policy rates. December 2020-July 2022
(Percentages and percentage points)

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official figures.

	Monetary policy rate, 31 December 2020 (percentage)	Beginning of the rate rise	Monetary policy rate, 15 July 2022 (percentage)	Variation (percentage points)	Number of rate increases	Average variation (percentage points)	Ratio between values at July 2022/ December 2020
Brazil	2.0	March 2021	13.25	11.25	11	1.02	6.6
Chile	0.50	July 2021	9.75	9.25	9	1.03	19.5
Colombia	1.75	October 2021	7.50	5.75	7	0.82	4.3
Costa Rica	0.75	December 2021	5.50	4.75	5	0.95	7.3
Dominican Republic	3.00	November 2021	7.25	4.25	6	0.71	2.4
Guatemala	1.75	May 2022	2.25	0.50	2	0.25	1.3
Honduras	3.00		3.00	0.00			
Jamaica	0.50	October 2021	5.50	5.00	7	0.71	11.0
Mexico	4.00	June 2021	7.75	3.75	9	0.42	1.9
Paraguay	0.75	August 2021	7.75	7.00	10	0.70	10.3
Peru	0.25	August 2021	6.00	5.75	12	0.48	24.0
Uruguay	4.50	August 2021	9.75	5.25	8	0.66	2.2

SECTION 3

Latin America and the Caribbean Overview

Energy and GHG Emissions Overview

Introduction

Total GHG emissions[1] are the sum of emissions of various gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), and the fluorinated gas such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), and Nitrogen trifluoride (NF_3).

Global greenhouse gas emissions by gas
2016

Source: Our World in Data

Methane Emissions
International Context

The impact of methane emissions on the rate of climate change has become more prominent in the broader public debate in recent years, due to the immediate climate benefit of reducing them.

Methane has a much shorter atmospheric lifetime than CO_2, around 10 years, and “its impact on climate is reversible”[2]. Methane has accounted for roughly 30% of global warming since pre-industrial times and is proliferating faster than at any other time since record keeping began in the 1980s.[3]

Annual global methane emissions are subject to a high degree of uncertainty, with the most recent estimation around 570 Mt[4]. About 60%-65% of methane emissions are due to human activities[5], while the remaining 35%-40% are from natural sources. Historically, methane emissions are more difficult to track compared to CO_2 emissions, these being mostly linked to economic activity. Agriculture[6] is the main source of methane emissions, responsible for about 25% of the total, followed by waste (10%), coal (8.0%), oil (7.2%), gas (7%), and bioenergy (2%). (The figures are for 2020 and 2021). Although in an aggregate visualization, energy (coal, oil, and gas) contributes around 24%, the technical and methane monetization capability differs substantially between the different fossil fuels, which leads us to different solutions in the short- and mid-term periods.

Annual global methane emissions **570Mt.**

60-65%
Anthropogenic emissions: landfills, oil and natural gas systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial processes.

35-40%
Natural sources

25%	10%	8%	7%	7%
Agriculture	Waste	Coal	Oil	Gas

[1] The Kyoto Protocol, an environmental agreement adopted by many of the parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 to curb global warming, nowadays covers seven greenhouse gases
[2] WMO, https://public.wmo.int/en/media/press-release/more-bad-news-planet-greenhouse-gas-levels-hit-new-highs.
[3] United NationsEnvironment Programme (UNEP), https://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them.
[4] IEA, Methane Tracker.
[5] United States Environmental Protection Agency (EPA): Anthropogenic emission sources include landfills, oil and natural gas systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial processes. https://www.epa.gov/gmi/importance-methane#:~:text=Methane%20is%20the%20second%20most,trapping%20heat%20in%20the%20atmosphere.
[6] UNEP, Agriculture includes livestock emissions and crops like paddy rice cultivation.

In October 2022, WMO raised the alert about record levels of GHG emissions, and in particular as regards methane, the organization highlighted:

"Since 2007, globally-averaged atmospheric methane concentration has been increasing at an accelerating rate. The annual increases in 2020 and 2021 (15 and 18 ppb respectively) are the largest since systematic record keeping began in 1983. Causes are still being investigated by the global greenhouse gas science community. Analysis indicates that the largest contribution to the renewed increase in methane since 2007 comes from biogenic sources, such as wetlands or rice paddies. It is not yet possible to say if the extreme increases in 2020 and 2021 represent a climate feedback – if it gets warmer, the organic material decomposes faster. If it decomposes in the water (without oxygen) this leads to methane emissions. Thus, if tropical wetlands become wetter and warmer, more emissions are possible." [7]

On the other hand, as a result of the Paris Agreement, 175 out of 189 countries mention action on methane emissions within their NDCs. However, very few have entered into details about how they would reduce methane emissions up to 2030. This reflects a broader challenge with the level of details and content of commitments included in NDCs, and a minority of countries have made no reference at all to these emissions in their NDCs.

Given this background, many governments have been keen to push international coalitions to work with industry to make bolder commitments, including both:

- Voluntary action within individual companies and countries; and
- Developing international minimum standards for methane emissions from oil and gas operations.

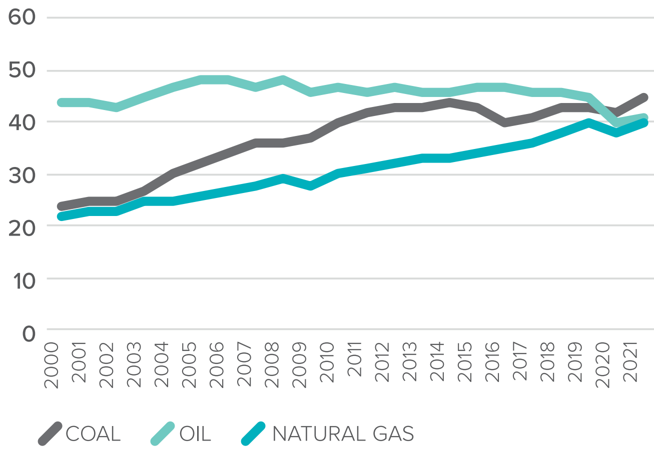
Nevertheless, at this point there is a relevant consideration to underscore. Methane is the main component of natural gas, consequently capturing and monetizing emissions is the best option, not only from the climate perspective but also from the economic perspective, given the existence of available technology. According to IEA, three-quarters of the emissions in the oil and gas sector could be captured with existing capabilities. Taking into account the number of industry commitments through different pledges, the progress is on track and policymakers and industry must work together to create the conditions to accelerate and facilitate the required investments.

Additionally, those emissions coming from manure and agro-industrial waste can be captured using anaerobic digestion (AD) technology (including small-scale digesters, covered anaerobic lagoons, plug flow digesters, complete mix digesters, and advanced digesters), and can generate energy for on-farm heating, cooling, and electricity needs[8] or can be injected into gas pipelines jointly with natural gas.

However, as raised by IEA in February 2023 in the document "Driving Down Coal Mine Methane Emissions", the coal situation is very different, and coal mine operations in 2022 represent more than 10% of total human emissions, being equivalent to around 1.2 Gt CO_2-eq1, or in other words, all the energy-related CO_2 emissions from Central and South America. As underlined in the aforementioned document, unlike oil and gas, the coal sector has more financial and technical barriers to reducing methane emissions. Consequently, addressing methane emissions from coal requires a strategy of transition to cleaner energies in the power sector, with mitigation strategies providing economic feasibility. Nevertheless, the lack of progress in the reduction of coal mine methane is highlighted by a lack of regulatory frameworks and unclear ownership structures of coal mines.

Methane Emissions
Mt

Source: IEA, "Methane emissions from fossil fuels in the Net Zero Scenario, 2000-2030" (Last updated 26.10.2022)



[7] https://public.wmo.int/en/media/press-release/more-bad-news-planet-greenhouse-gas-levels-hit-new-highs.
[8] Global Methane Initiative, "Agricultural Methane: Reducing Emissions, Advancing Recovery and Use Opportunities".

Methane Emissions – international coalitions that drive further action

Climate & Clean Air Coalition Mineral Methane Initiative (CCAC MMI)

A voluntary partnership of governments, intergovernmental organizations, businesses, scientific institutions, and civil society organizations committed to improving air quality and protecting the climate through actions to reduce short-lived climate pollutants. The Coalition includes 77 state partners and 78 non-state partners (international NGOs and other NGOs).

Global Gas Flaring Reduction Partnership (GGFR)

A multi-donor trust fund established by the World Bank Group and composed of governments, oil companies, and multilateral organizations committed to ending routine gas flaring at oil production sites across the world. The Partnership includes 20 governments, 12 companies, and three multilateral organizations.

Global Methane Pledge

President Biden and President Von der Leyen announced at the Major Economies Forum (MEF) meeting on 17 September 2021 that the USA and EU would invite countries to support the Global Methane Pledge to be launched at COP26 in November 2021 in Glasgow.
Participants joining the Pledge agree to take voluntary actions to contribute to a collective effort to reduce global methane emissions at least 30% from 2020 levels by 2030, which could eliminate over 0.2°C of warming by 2050. This is a global, not a national reduction target. Participants also commit to moving towards using the highest tier IPCC good practice inventory methodologies, as well as working to continuously improve the accuracy, transparency, consistency, comparability, and completeness of national GHG inventory reporting under the UNFCCC and Paris Agreement, and to provide greater transparency in key sectors.

With over 100 countries on board, representing nearly 50% of global anthropogenic methane emissions and over two-thirds of global GDP, the initiative is on the way to achieving the Pledge goal and preventing more than 8 Gigatonnes (Gt) of CO_2e emissions from reaching the atmosphere annually by 2030.

Global Methane Initiative (GMI)

An international public-private partnership focused on reducing barriers to the recovery and use of methane as a valuable energy source. GMI provides technical support to deploy methane-to-energy projects around the world that enable partner countries to launch methane recovery and use projects. GMI focuses on three key sectors: oil and gas, biogas, and coal mines.

Ipieca

Ipieca is the global oil and gas association dedicated to advancing environmental and social performance across the energy transition. It brings together members and stakeholders to lead in integrating sustainability by advancing climate action, environmental responsibility, and social performance across oil, gas, and renewables activities.

Ipieca was founded at the request of UNEP in 1974. Through its non-lobby and collaborative approach, Ipieca remains the industry's principal channel of engagement with the UN.

Oil and Gas Climate Initiative (OGCI)

A CEO-led organization bringing together 12 of the largest oil and gas companies worldwide to lead the industry's response to climate change.

Oil and Gas Methane Partnership (OGMP)

The Oil & Gas Methane Partnership 2.0 (OGMP 2.0) is a multi-stakeholder initiative launched by UNEP and CCAC. OGMP 2.0 is the only comprehensive, measurement-based reporting framework for the oil and gas industry that improves the accuracy and transparency of methane emissions reporting in the oil and gas sector.
Over 80 companies with assets on five continents, representing a significant share of the world's oil and gas production, have joined the Partnership. OGMP 2.0 members also include operators of natural gas transmission and distribution pipelines, gas storage capacity, and LNG terminals.
OGMP non-company members include UNEP, the Environmental Defense Fund (EDF), European Commission, CCAC and Clean Air Task Force (CATF).

Methane Guiding Principles

The Methane Guiding Principles drive efforts in five priority areas to reduce methane emissions from natural gas:
1. Continually reduce methane emissions;
2. Advance strong performance across the gas value chain;
3. Improve accuracy of methane emissions data;
4. Advocate sound policy and regulations on methane emissions;
5. Increase transparency and reporting.

The initiative includes 27 signatory companies and 21 supporting organizations, including IEA, EDF, UNEP, World Bank, and RMI (Rocky Mountain Institute), as well as academic institutions. This voluntary initiative strengthens the coalition between industrial members and other interest groups, focusing on priority areas to reduce methane emissions through the entire value chain, from production to the final consumer.

IGU supports the Methane Guiding Principles workstream to assist with operationalizing the Global Methane Pledge (GMP). GMP has been signed by 63 IGU member countries.

Methane Observatory in Latin America and the Caribbean (OLADE)

In December 2022, the Ministers of Energy of OLADE's member countries instructed the organization to establish a Latin American regional office for the collection, monitoring, and supervision of information on methane emissions through which the different OLADE member countries are advised and supported in emission reduction measures.
The Observatory will work within the framework of OLADE and will have as strategic partners ARPEL, CAF, and CATF, among others.

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CO_2 Emissions
International Context

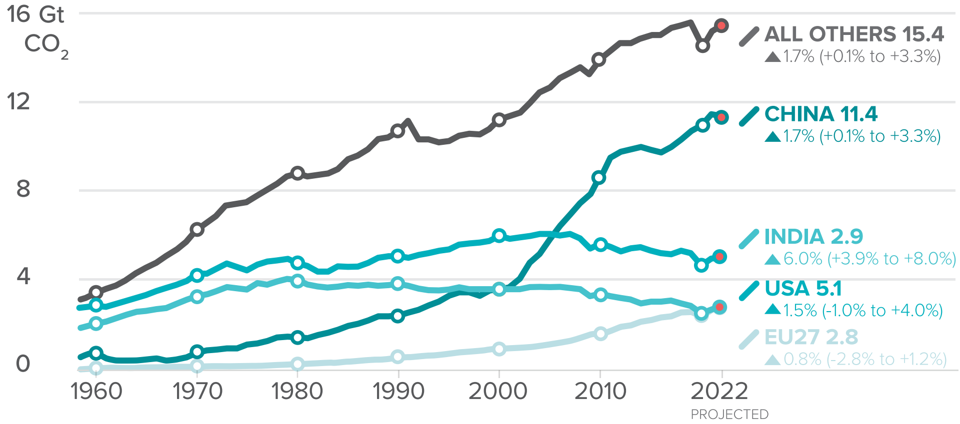
It is widely recognized that to avert the worst climate impacts the world needs an urgent reduction in CO_2 emissions, which are the primary driver of global climate change. The shared responsibility between regions and countries is at the forefront of the international discussions.

The decline in energy consumption per unit of GDP can help in the reduction of the rate of growth of emissions; energy efficiency is a good lever to keep emissions under control, while not limiting economic growth. However, it is worth mentioning that the rate of increase of CO_2 emissions changed drastically in the decade 2000-2010 as China's[8] economy boomed based on coal as the main fuel. Today, global CO_2 emissions appear to be going back to the pre-2000 rate. However, global CO_2 emissions from coal, the larger emitter today, are expected to rise, not having reached the global peak yet with the current net-zero commitments of the main coal consuming countries. Furthermore, India's emissions are in the same range as those of the EU, representing the principal growth in relative terms.

However, a deep analysis of the EU and USA shows a declining emissions trend in the last 15 years, owing to better efficiencies in oil consumption and coal substitution in power generation with cleaner energies.

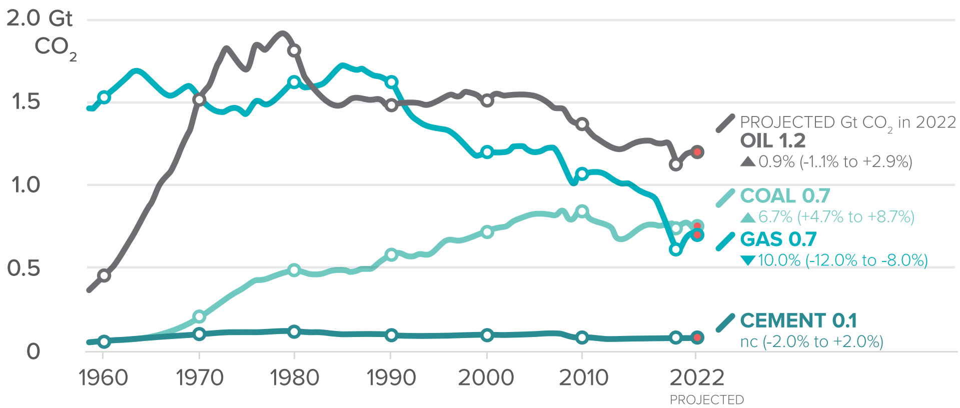
Annual Fossil CO_2 Emissions and 2022 Projections
Projected global emissions growth:
+1.0% (+0.1% to + 1.9%)

Source:
Global Carbon Project.
Global Carbon Budget 2022



Annual Fossil CO_2 Emissions in European Union (27)
Projected global emissions growth:
-0.8% (-2.8% to + 1.2%)

Source:
Global Carbon Project.
Global Carbon Budget 2022

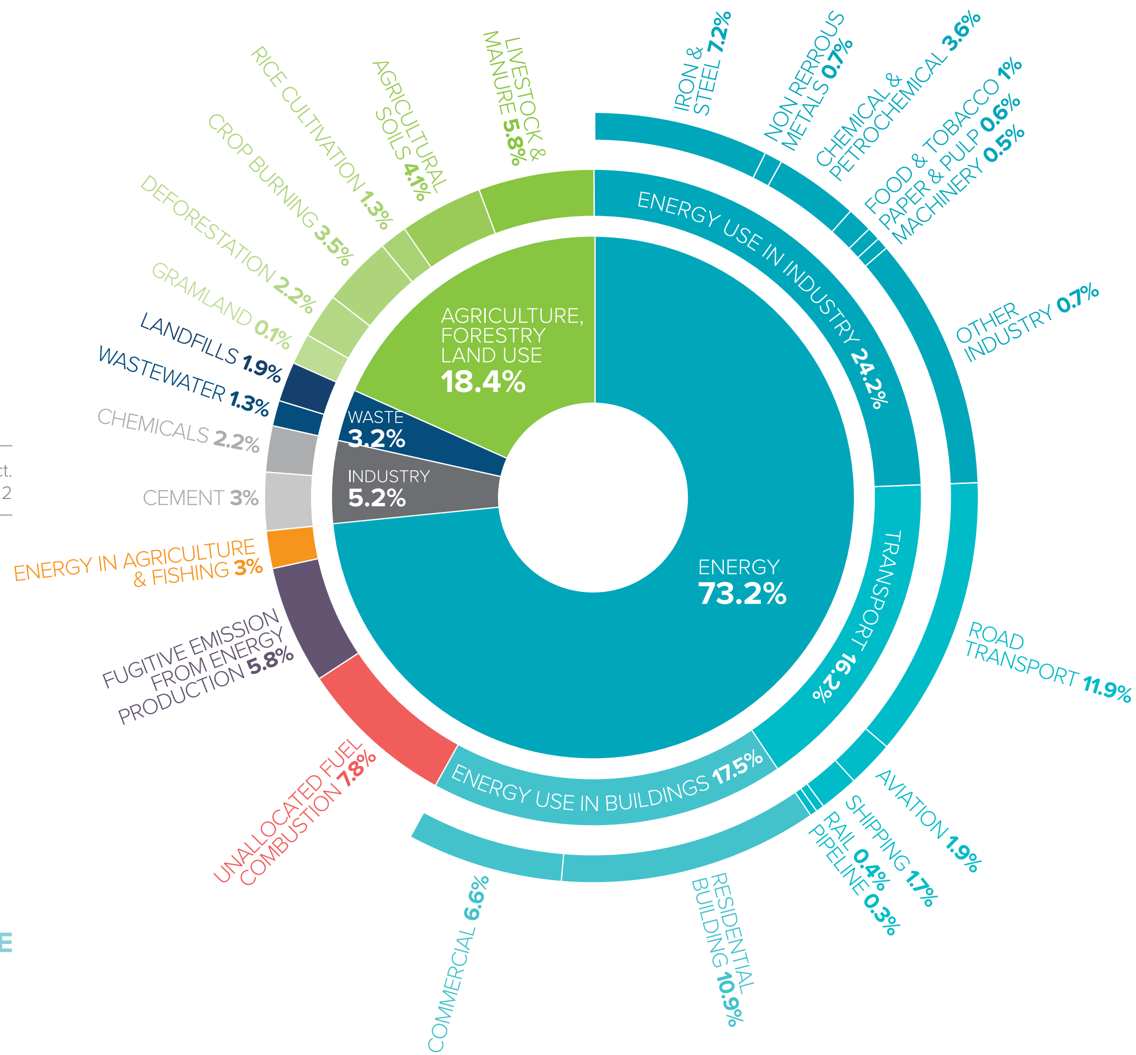


[8] Global Carbon Budget 2022.
https://www.globalcarbonproject.org/carbonbudget/22/presentation.htm

Global CO_2 emissions growth has generally resumed quickly from global crises. GHG emissions intensity of GDP has steadily declined but not sufficient to offset economic growth.

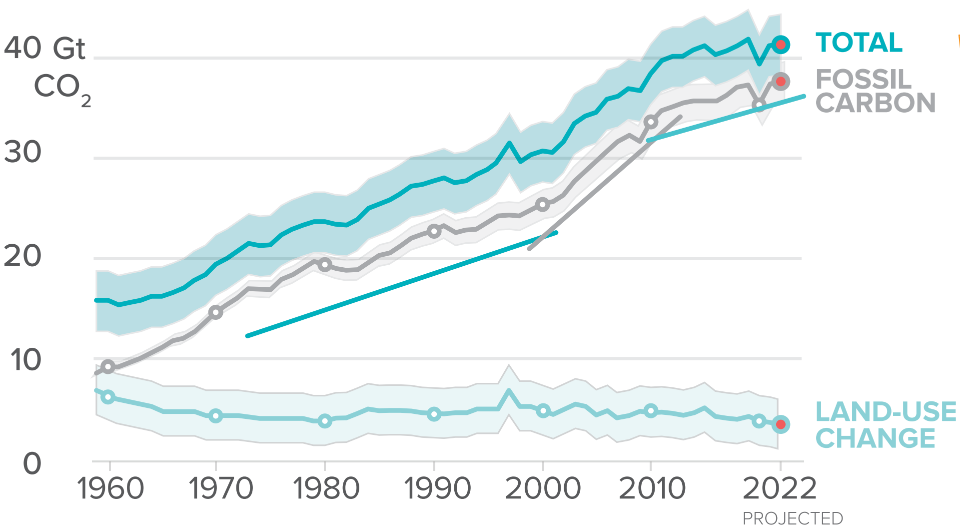
Global greenhouse gas emissions by sector

Source: Our World in Data 2022
https://ourworldindata.org/emissions-by-sector.



Annual CO_2 Emissions

Source: Global Carbon Project.
Global Carbon Budget 2022



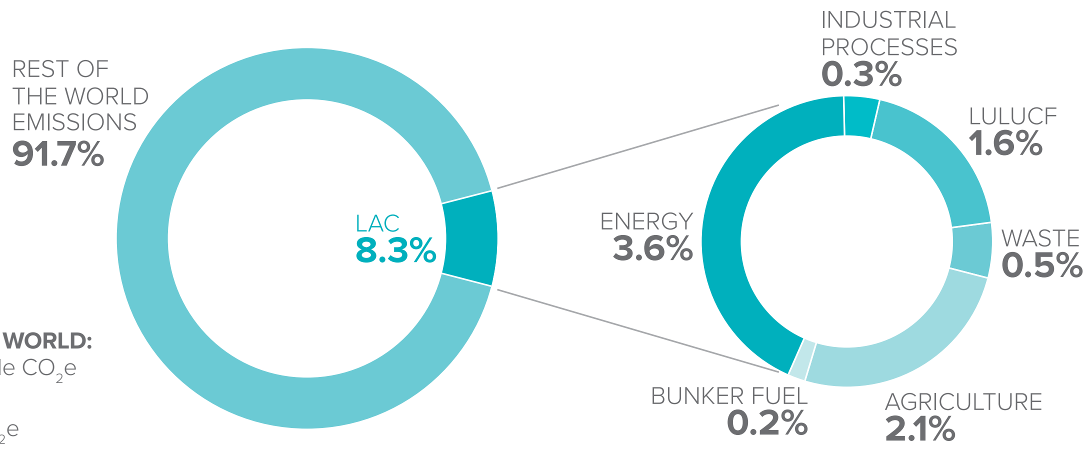
Latin America and the Caribbean
Primary Energy and Emissions Overview

The Latin America and Caribbean region contributes approximately 8% of the world's total GHG emissions annually[10]; however, less than half of these emissions are derived from energy use. On a global scale, the energy industry is the single main emitter. **However, while energy accounts for 73% of global GHG emissions, in Latin America and the Caribbean this figure is much lower, representing just 43% of the region's total emissions.** The main reasons for this are that the energy supply is of lower carbon intensity, typically with a greater share of hydropower and natural gas rather than coal, and the bigger impacts of other activities such as agriculture, and deforestation, mainly of the Amazon rainforest.

Fossil fuels account for 65% of the total primary energy supply in Latin America and the Caribbean. The share of natural gas is 29% and that of oil 31%, while coal's share is only 5% (OLADE). As the region is an exporter of raw materials and agricultural products and because of long distances to export terminals, complex geography, and the lack of rail infrastructure, around 85% of gross tonne-km[11] are transported by trucks in all major economies in the region (UNEP)[12]. They are fueled by diesel. The situation is no different in the rest of the region. Transport accounts for 37% of energy use and 40% of GHG emissions in the region (OLADE)[13], being one of the priority sectors for decarbonization, and where outstanding opportunities arise for natural gas, both in road and maritime transport.

World vs LAC GHG Emissions
2019

Source: OLADE, 2022, "Panorama energético de América Latina y Caribe".

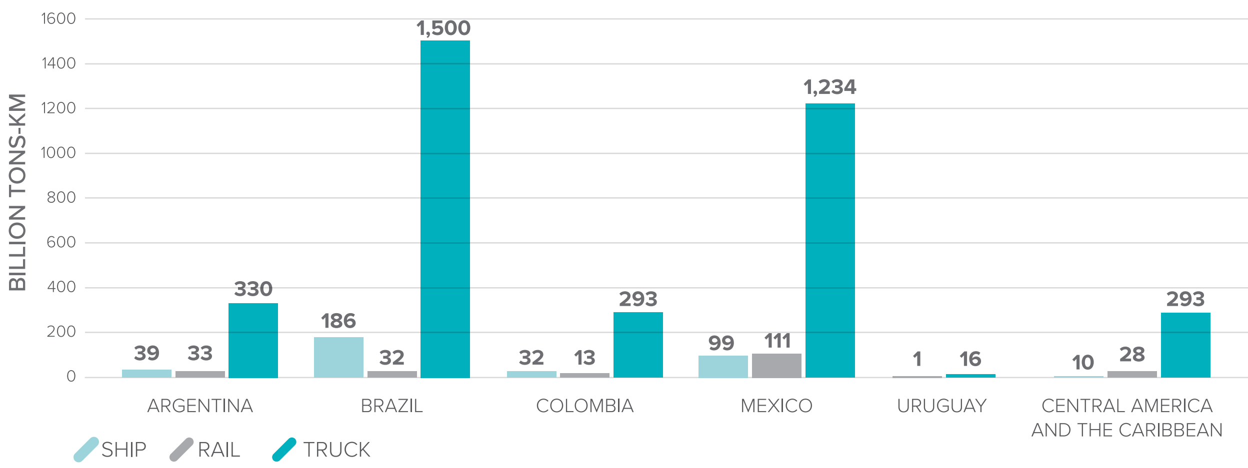


REST OF THE WORLD:
49,758.23 Mt de CO_2e

LAC:
4,117 Mt de CO_2e

Estimated cargo transported (in billion tons-km) in selected LAC countries.

Source: UNEP. Data: GCAM, 2015.



[10] OLADE
[11] Gross tonne-km is the product of total weight (including the weight of lading cars and locomotives) and the distance traveled by a train or a truck
[12] UNEP, https://www.unep.org/es/resources/informe/carbono-cero-america-latina-y-el-caribe.
[13] OLADE, 2022, "Panorama energético de América Latina y Caribe", https://www.olade.org/wp-content/uploads/2023/01/Panorama-ALC-13-12-2022.pdf.

In the power sector, hydropower accounts for 43% of power supply, which makes the region's energy supply relatively clean, but also more vulnerable to droughts and other climate phenomena like El Niño and La Niña. Other renewable energy accounts for 16% of the power supply. While some countries like Costa Rica, Uruguay, Brazil, Chile, or Argentina have made great progress, there is still a lot of renewable potential to be developed; and a lot of oil and coal to be substituted. The region's exceptional decarbonized power sector is described in the Power chapter of this white paper.

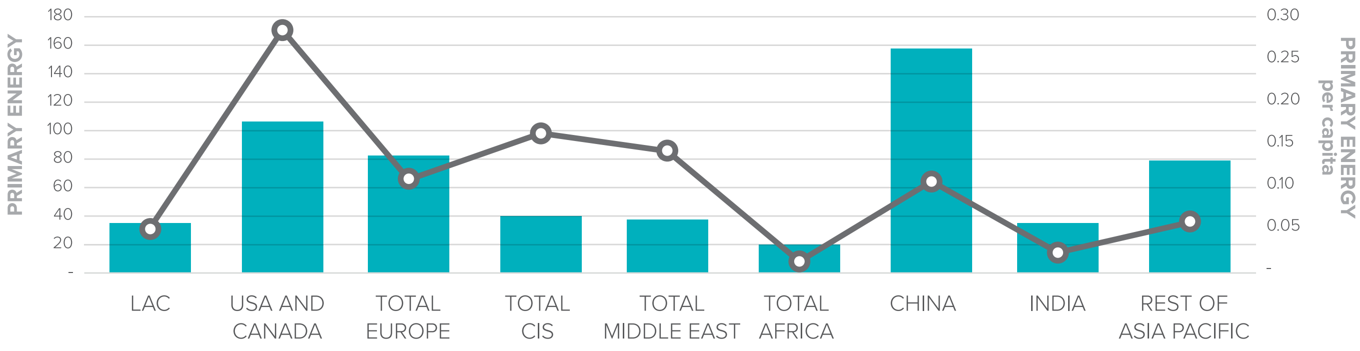
Primary energy consumption per capita in Latin America and the Caribbean is lower than in other regions. It is worth pointing out that China has reached the same level of primary energy consumption per capita as Europe (0.11 Exajoules per capita). However, this is still half that of the USA and Canada (0.28 Exajoules per capita).

Access to electricity in the region is relatively high, reaching almost 100% in the Southern Cone, Brazil, and Mexico, while there are still significant gaps in the Andean Region, Central America, and the Caribbean, because of the lack of quality infrastructure to reach sparse, rural, and poor populations. Access to clean cooking is also a challenge in these sub-regions, with its associated health and inequality issues.

Latin America and the Caribbean is a resource rich region with a relatively low carbon-intense energy system and with important economic and social development challenges to overcome. This has critical implications for climate action in the region, and natural gas has a key role to play, contributing to advances in the dual challenges of decarbonization and economic development.

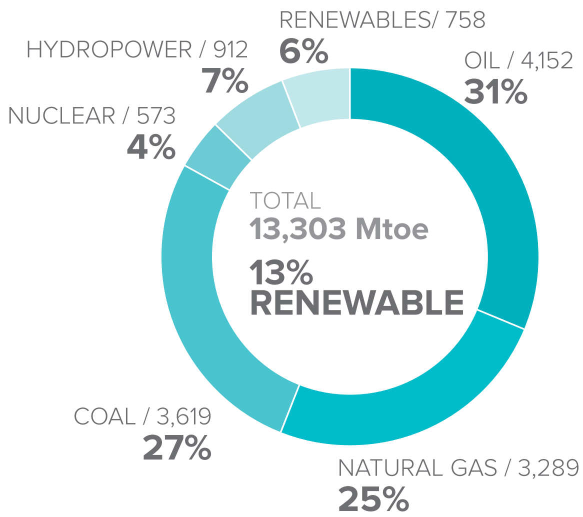
Primary Energy Consumption
Exajoules

Data Source: BP Statistical Review of World Energy 2022



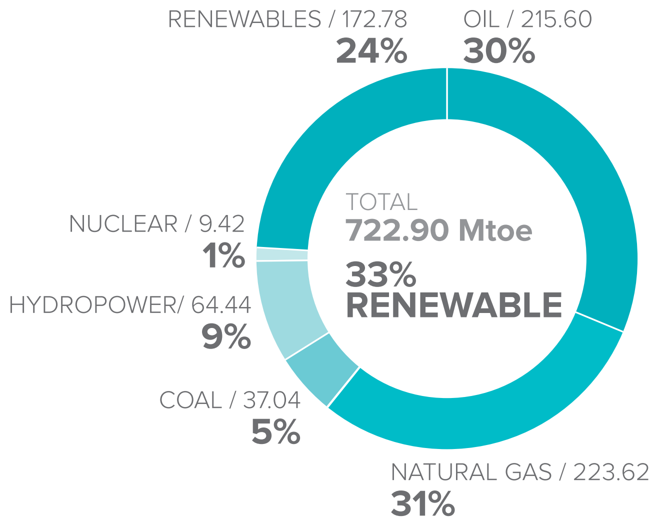
Total Primary Energy Supply (World)
Mtoe; %. 2020

Source: OLADE



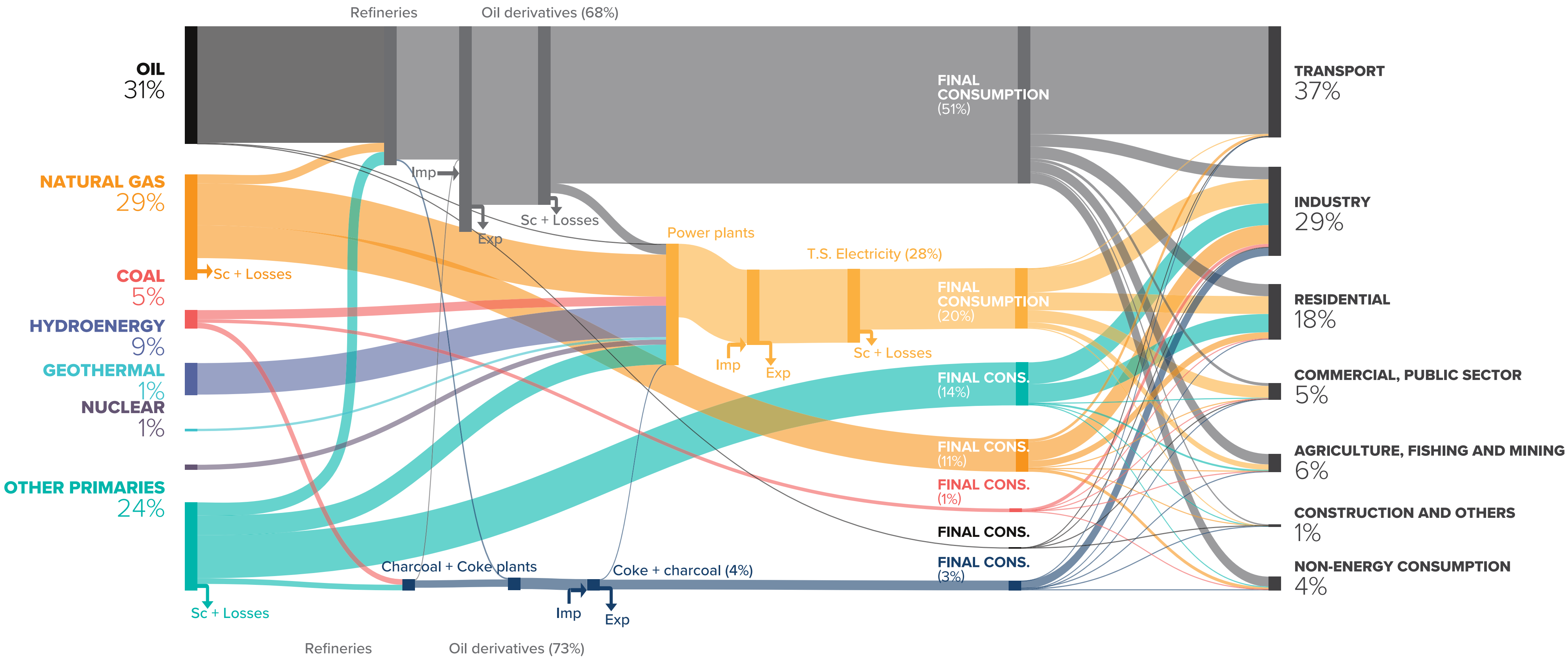
Total Primary Energy Supply (LAC)
Mtoe; %. 2020

Source: OLADE



Latin America and the Caribbean Energy Balance
2021

Source: OLADE, 2022 "Panorama energetico de America Latina y Caribe"



SECTION 4

Key Drivers for Natural Gas Development and Decarbonization

SECTION 4

Key Drivers for Natural Gas Development and Decarbonization

Gas Resources Development for Economic Prosperity

Monetizing natural gas resources

The natural gas resources of Latin America and the Caribbean have the potential to facilitate the region's socio-economic growth, boosting industry and facilitating energy access, while serving at the same time to decarbonize both national and overseas economies. Many nations are therefore seeking to enhance investment opportunities in order to monetize their resources, making them more bankable and attractive for investors.

However, on the road to select a suitable gas reserve for monetization, there are many constraints to overcome, including technology, resource size and quality, location, capital costs, and fiscal regimes. The absence of infrastructure and gas markets can also derail investment momentum. Macroeconomic signals, country credibility, demand predictability, regulatory frameworks, and sentiment about the role of natural gas in the energy transition are substantial boundary conditions that can hinder its development.

Labeling natural gas projects in the whole gas value chain as "green" investments with high standards requirements (best in class) to minimize its environmental footprint is key to decarbonize the economies in time.

IEF, in its recent Upstream Oil and Gas Investment Outlook[1], suggests that "Traditionally, decisions to invest in long-cycle upstream projects consisted of balancing economic considerations such as full-cycle breakeven prices and above-ground risk affecting developments. Now, investment decision-makers must also consider if demand will still be there over the lifetime of a specific project and the impact of government policy changes."

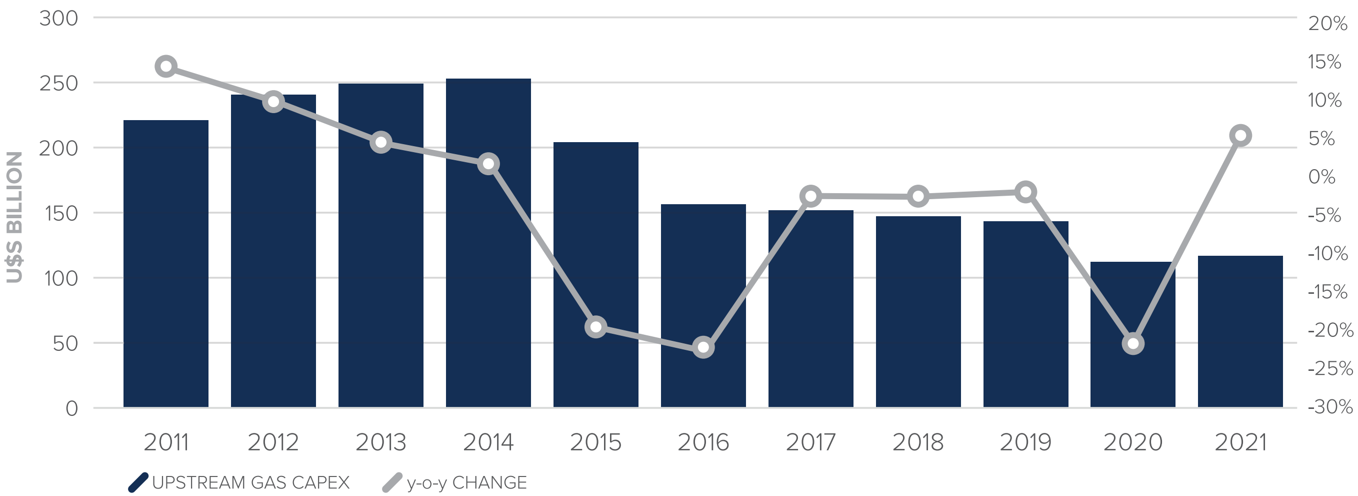
Underinvestment in the upstream sector can lead to recurrent price shocks across all commodities, exacerbating volatility, undermining energy security, and fostering the use of other more polluting fuels.

The Gas Exporting Countries Forum (GECF)[2] highlights declining investment since 2014 as the major contributor to rocketing prices in 2021 and natural gas shortages, following the rapid post-pandemic economic recovery.

As a result, in 2022, **energy security emerged as a strategic priority,** with an acceleration of LNG midstream infrastructure development plans to 2030, and a stimulus for new E&P projects.

Upstream Natural Gas CAPEX

Source: GECF. Global Gas Outlook 2050. Feb.23



[1] IEF, Upstream Oil and Gas Investment Outlook, Investment Needs Rise Amidst Market Uncertainty. February 2023.
[2] GECF, Global Gas Outlook 2050. January 2023.

Gas Reservoirs

A natural gas reservoir is composed of porous and permeable rocks that can hold significant amounts of natural gas confined by impermeable rock or water barriers. There is a distinction between conventional and non-conventional reserves[3]:

Conventional gas is trapped in naturally porous reservoir formations that are capped with impermeable rock strata. When intercepted by a well, gas is able to move to the surface without the need to pump.

Unconventional gas is formed in more complex geological formations which limit the ability of gas to migrate and therefore different methods are required to extract the gas. There are several types of unconventional gas, including shale gas and tight gas, which occur in reservoirs with very low permeability compared to conventional reservoirs. In these geological formations, horizontal drilling and hydraulic fracturing are often necessary for economic gas extraction.

Proved reserves are defined as volumes of natural gas that analyses of geological and engineering data demonstrate to be recoverable under existing economic and operating conditions. The new technologies, additional successful exploratory wells, and increases in prices for natural gas can change previously uneconomic natural gas resources into proved reserves. Following the conventional definition of reserves by the Society of Petroleum Engineers (SPE), Reserves covers the project status sub-classes "On production", "Approved for development", and "Justified for development".

In addition to Proved Reserves (1P), there are two other categories. Probable Reserves (2P) are those additional Reserves which analysis of geoscience and engineering data indicate are less likely to be recovered than Proved Reserves but more certain to be recovered than Possible Reserves. In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual quantities recovered will equal or exceed the 2P or P1+P2 estimate. Possible Reserves (3P) are those additional Reserves that analysis of geoscience and engineering data suggest are less likely to be recoverable than Probable Reserves. When probabilistic methods are used, there should be at least a 10% probability that the actual quantities recovered will equal or exceed the 3P or P1+P2+P3 estimate.

Global production has been growing since the 2008 financial crisis, due to the progress of shale fracking in the USA. And IEA recognizes that natural gas has contributed to almost one-third of overall energy-demand growth in the last decade.

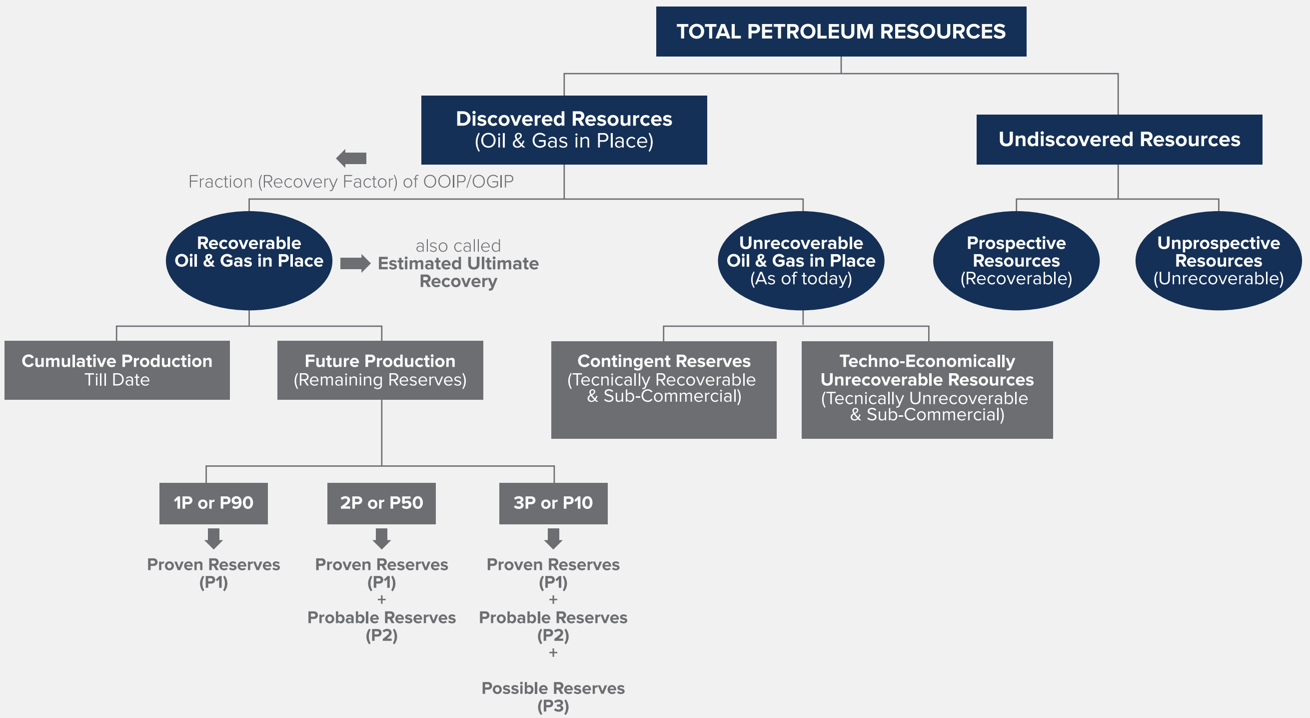
As of today, global Proven Natural Gas Reserves (P1) could be estimated at around 7,500 tcf[4]. Latin America and the Caribbean represents approximately 4.3% of this. However, a consideration of only P1 reserves could lead to an underestimation of potential for commercial gas reserves in the region; this figure could increase significantly once the unconventional gas of Argentina is developed, moving the status of its reservoirs from P2 and P3 to P1. As highlighted by the US Energy Information Administration (EIA), Argentina is home to the world's second largest shale gas reserves, the Vaca Muerta play, located in the Neuquen Basin, with an estimated 308 Tcf[5] of dry, wet, and associated shale gas resources.

Additionally, the methodology used to modify the status of conventional and unconventional gas reserves from 3P, to 2P to 1P is governed by different criteria, more restricted for unconventional resources, and this can lead to underestimating the potential contribution of unconventional gas to the economies.

[3] EPA, Environment Protection Authority US.
[4] Average information several resources: Oil & Gas Survey, US Energy Information Administration.
[5] US EIA, "Growth in Argentina's Vaca Muerta shale and tight gas production leads to LNG exports" July, 2019.

Hierarchy Tree and Venn diagram. Hydrocarbons reserves and resources[6]

Source: https://www.hoec.com/demystifying-resources-and-reserves-in-oil-gas/

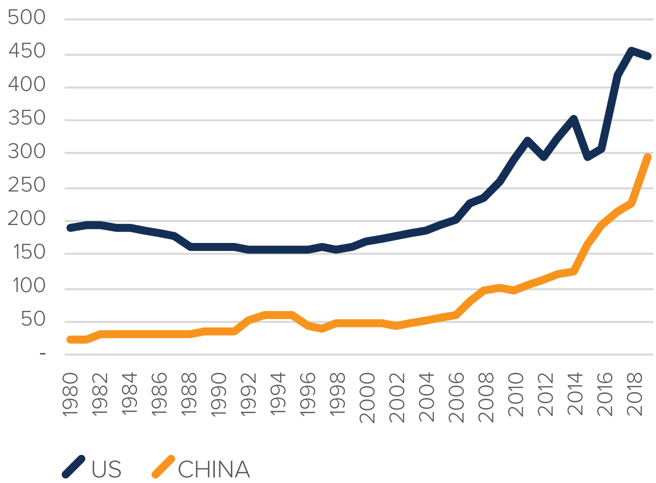


On the other hand, favorable market prices, supported by extensive Research and Development for commercial extraction, facilitate status modification from resources to reserves (P1, P2, P3) or a category change in the reserve group. This is well exemplified by the proven reserves evolution of the two biggest worldwide economies, the US and China.

Proven Reserves

Tcf

Data Source: BP Statistical Review of World Energy 2022 [7]

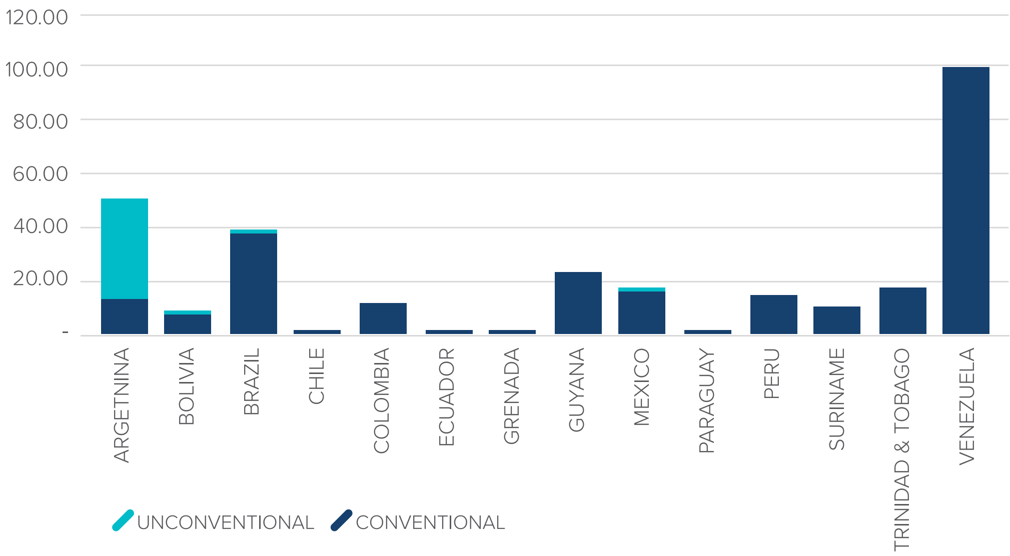


[6] "Demystifying resources and reserves in Oil & Gas".
[7] US EIA, Wet natural gas proved reserves US (473 tcf) vs BP Statistical Review of World Energy (446 tcf).

Reserves and production levels in Latin America and the Caribbean are driven by Argentina, Bolivia, Brazil, Colombia, Mexico, Peru, Trinidad & Tobago, and Venezuela. These countries, together with the recent addition of Guyana, account for more than 99% of the region's reserves.

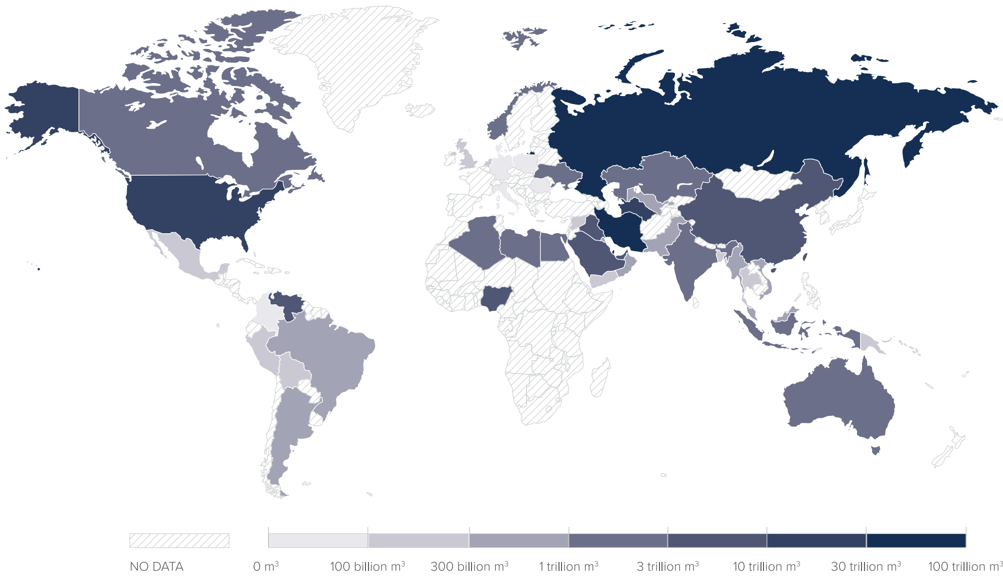
Commercial + Technical Reserves
Tcf

Source: Wood Mackenzie, Lens Upstream, 17 February 2023[8]



Natural Gas Reserves

Source: Our World in Data https://ourworldindata.org/grapher/natural-gas-proved-reserves



Venezuela is the only country from the Latin American and Caribbean region in the top 10 countries when it comes to natural gas reserves[9]; however, from a production standpoint, it sits down at number 32, with a contribution of only 0.6% of global gas production.

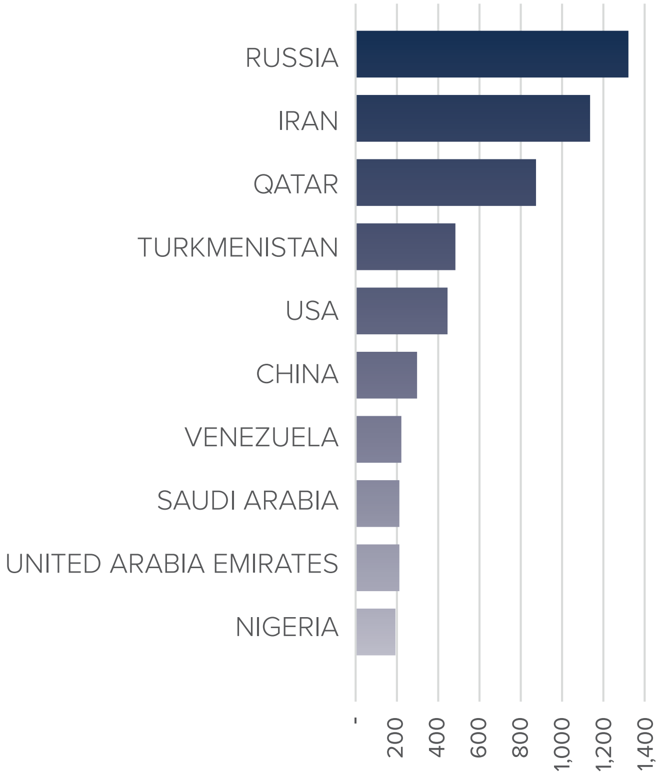
Conversely, according to the BP Statistical Review of World Energy 2022, Norway, with proven reserves that place it in 21st position, appears in ninth place on the producer list.

LAC proven reserves:	Norway proven reserves:	LAC production:	Norway production:
285 Tcf	**51 Tcf**	**11 bcf**	**18 bcf**

[8] Wood Mackenzie: Venezuela (commercial and technical) resources assumption severely constrained by appetite for exploration and current low levels of drilling activity, under current warrant framework. Other Venezuela sources of information, without this consideration (proven reserves 220 Tcf).
[9] BP Statistical Review of World Energy, Venezuela with constant trend in the last 10 years for its gas reserves evaluation.

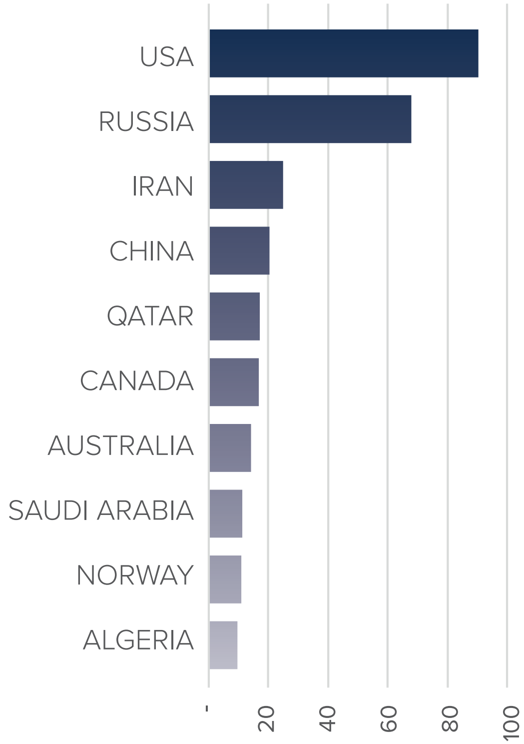
Top 10 countries, Proven Gas Reserves (1P)
Tcf

Data Source: BP Statistical Review of World Energy 2022



Top 10 Gas producers
bcfd - 2021

Data Source: BP Statistical Review of World Energy 2022



Capital and Risk Intensive Businesses

E&P of natural gas involves high levels of capital and is subject to several uncertainties, including those related to the physical characteristics of the gas fields and issuance of permits and licenses. Deep and ultra-deep water operations, or those in remote and challenging locations, may take time to develop before commercial production of reserves can take place, increasing both operational and financial risks.

Introduced in the 1980s, in response to chronic global exploration underperformance, E&P risk analysis integrates the fields of statistics, geoscience, engineering, and economics. The diversification of risks in the E&P business for the prospecting and exploitation of resources involves different public, private, national, and international players, for the development of resources in the most efficient way, under a cooperative approach with the best technological capacities and capabilities to facilitate the economic viability of new projects. This is an activity that is highly dependent on the rate of success of exploratory management and the recoverability rate of the wells.

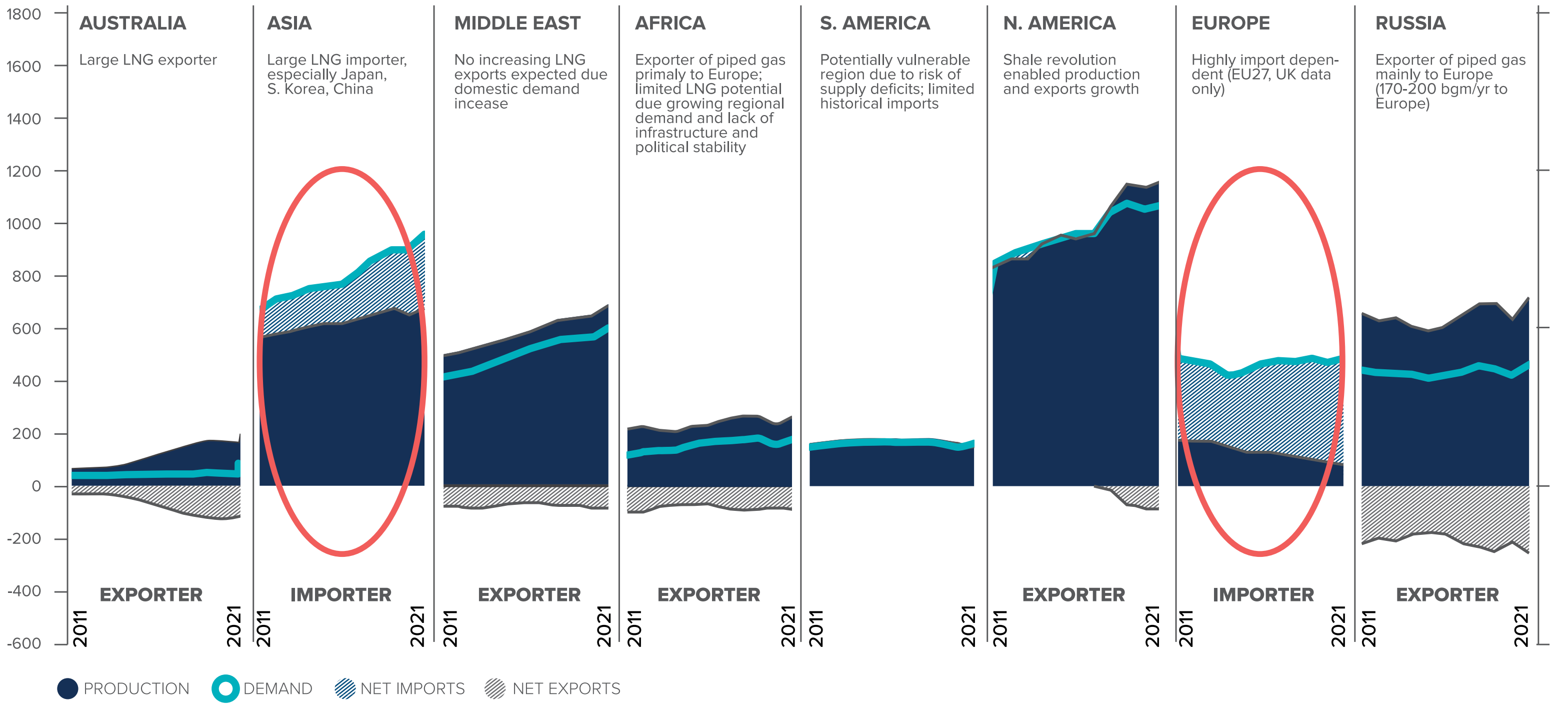
The ability to build transport infrastructure to export production to final markets, as well as the development of reliable spot markets with long-term commercial arrangements may be necessary to support the progress and marketing of particular gas projects.

E&P in Latin America and the Caribbean presents an excellent opportunity to follow the main economies in the success of monetizing gas reserves.

In the next graph, a deeper analysis by Rystad, related to production and consumption in each area, reveals that an increase in production in Latin America and the Caribbean could lead to more internal natural gas consumption and/or a net exporter position.

Global Natural Gas Balances 2011-2021
bcm/a

Source: Rystad 2022



Countries with an existing track record in E&P, together with the presence of public-private, and local-international players (Argentina, Bolivia, Venezuela, Brazil, Peru, and Trinidad & Tobago) can foster the deployment of the latest infrastructure, leveraged on the current gas pipeline network and LNG facilities, and using the most recent technologies.
Additionally, the expansion of LNG exports outside of Latin America and the Caribbean (today the only LNG exporters are Peru and Trinidad & Tobago) could boost the role of the region in the international energy arena (there is potential for Mexico, Argentina, and Venezuela among others). If this investment opportunity is not taken in the coming years, the economic potential of the region's gas reserves could be replaced by other energy sources.
The development of gas resources will support Latin America and the Caribbean in expanding its industrial sector (offtakers) and needed infrastructure, with a limited energy cost (own gas resources) and a subsequent benefit for the region through the huge potential of biogas, biomethane, and hydrogen (low-carbon gases). This, together with the most decarbonized power matrix in the world, would put the region at the forefront of sustainable growth.

SECTION 4

Key Drivers for Natural Gas Development and Decarbonization

Gas-to-Power

Power sector
International Context

One of the most important legacies of COP26 was the determination to target coal generation. After maybe the most difficult discussions in the international arena, with the differences between the meaning of phase out and phase down, the 197 parties managed to strike an agreement, which for the first time accelerates the phase down of unabated coal power. In the document "Fostering Effective Energy Transition, 2021", the World Economic Forum highlights the necessity to identify viable ways for the early retirement of coal generation as the main carbon-intensive assets in power generation, with an upward trajectory in the last 10 years.

A deeper analysis of global power production can help us understand how new power production is supplied and, what is more significant, if some of the market signals that policymakers are giving are effective or not in advancing the climate change fight.

World electricity generation in 2021 increased by 1,577 TWh vs 2020, where 51% of this extra generation was produced by coal, 32% by renewables and only 9% by gas. In terms of countries, four represented 70% of the power generation increase (China, India, USA, and Russia). And according to IEA[1], coal is both the largest emitter of energy-related global CO_2 – 15 Gt in 2021 – and the largest source of electricity generation, accounting for 36% in 2021, as well as being a significant fuel for industrial use.

In the first place, these figures highlight the relevance of energy access and demographic growth; if this growth is faster than the deployment of renewable capacity, the gap to provide energy has to be supplied by another source. When there is free thermal capacity, the spread between coal and gas prices, supply bottlenecks, the existence or not of CO_2 markets, the availability to respond and modulate in a faster way with less energy consumption, as well as former long-term commitments in some countries with coal power purchase agreements (PPAs), determine the technology that maximizes its use.

Coal is the largest CO_2 emitter in the energy sector, with 15 Gt in 2021.

Despite the new renewable capacity, the additional electricity demand was supplied with more than 50% based on coal generation.

The commodity crisis, starting in 2021, with an imbalance between supply and demand, has led to a switch from gas to coal in several economies, aggravated in 2022 by the Russia-Ukraine conflict.

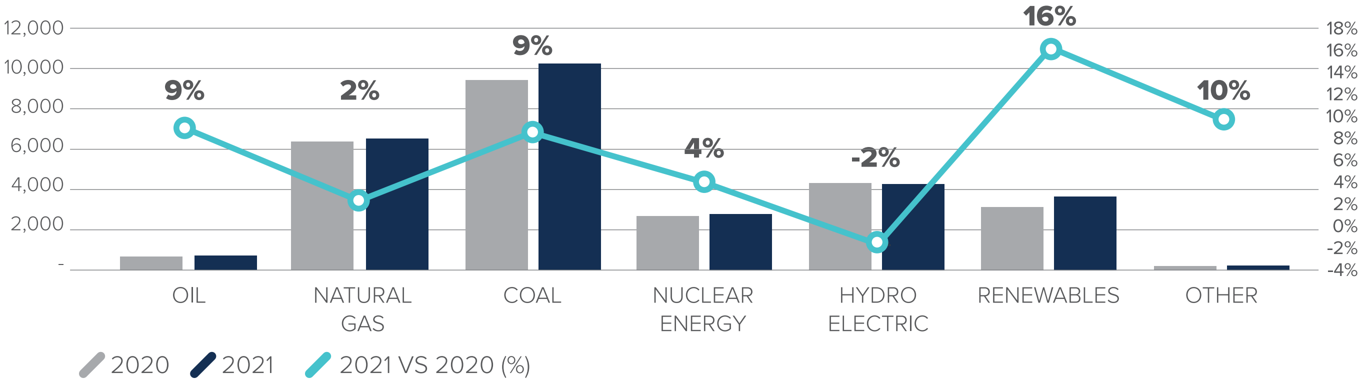
The situation in the USA is remarkable, where gas generation fell 3% in 2021 vs 2020, while coal generation increased 16%, leading to more CO_2 emissions. In the EU, the comparison between 2021 and 2020 shows an increase of 6% for coal generation.

From the climate perspective, we cannot go one step back increasing coal generation to the detriment of gas generation. And it is worth mentioning that coal not only represents the main emitter of CO_2 in the power sector, but also the main emitter of methane leakage from open coal mines, as IEA[2] highlights. Consequently, given the present situation, an international agreement is imperative to align the mismatch between the number of years to avoid the 1.5°C breach (before 2030) with the coal phase-down commitments for decades later.

[1] IEA, Coal in Net Zero Transitions, November 2022.
[2] IEA, Driving down coal mine methane emissions, February. 2023.

Electricity production
(TWh)

Data Source: BP Statistical Review of World Energy 2022



World electricity generation in 2021 increased by 1,577 TWh vs 2020, where 51% of this extra generation was produced by coal, 32% by renewables and only 9% by gas.

To facilitate this transition, renewable generation jointly with natural gas play a crucial role to decarbonize the power sector and modify the increased emissions trend of the most polluting countries. Recently, the Indian government announced plans to reduce its coal power generation (as of today, 74% of the power energy mix is coal-based) towards an economy where natural gas can support the stability of the power grid with renewable penetration, and it is expected that its energy mix will rise from 6% gas in 2021 to 15% in 2030. India is the world's third-largest energy consuming country after China and the USA, being as well, the third largest emitter of CO_2 by volume; although its emissions per capita are lower than the world average. According to IEA[3], China is forecast to install almost half of new global renewable capacity between 2022 and 2027, increasing by almost 1,070 GW, as guided in the 14th Five Year Plan on renewable energy, released in June 2022.

However, the beauty of renewable capacity deployment cannot always lead us to think about a similar growth of renewable capacity production. The example of the hydric stress provoked due to climate change can result in a drop in hydroelectric production as seen in 2021, forcing us to look at more back-up solutions to build a resilient power energy mix to avoid electricity blackouts or load shedding.

In 2021, the four countries with the greatest coal generation expansion were China, India, the USA, and Russia. While the first two had an overall 10% increase in power production, it was only 3% for the USA. And although there are more than 12 countries with over 30% of their power energy mix based on coal, just three countries (China, India, and the USA) account for 74% of coal generation production in the world. For each of these three coal's share is 63% in China, 74% in India, and 22% in the USA.

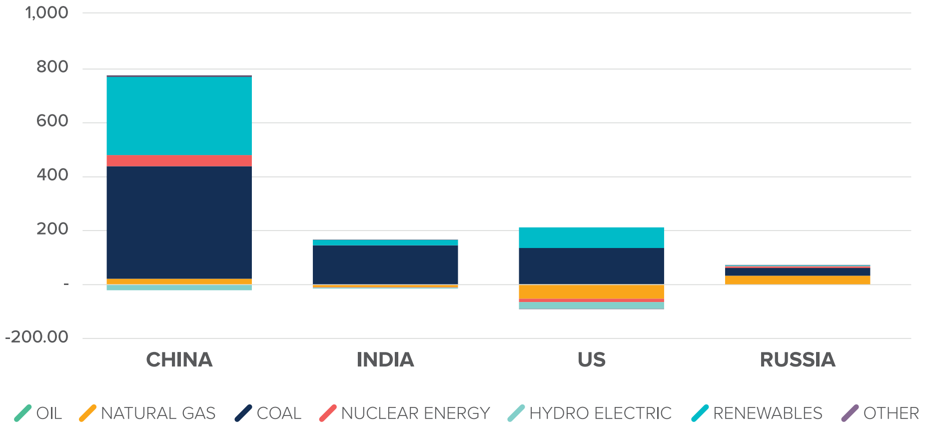
Even though China is increasing the deployment of renewable capacity, this is still not enough to meet the new power demand of the country and it is forced to supply 50% of the extra power demand with coal. This results in a generation of almost 5,339 TWh by coal generation in China, more than 4.2 times that of India (1,271 TWh) and 5.5 times that of the USA (978 TWh).

Counting the four countries (China, India, the USA, and Russia), the outcome results in 11 TWh less of gas generation and 726 TWh more of coal generation.

[3] IEA, Renewables 2022, analysis and forecast 2027.

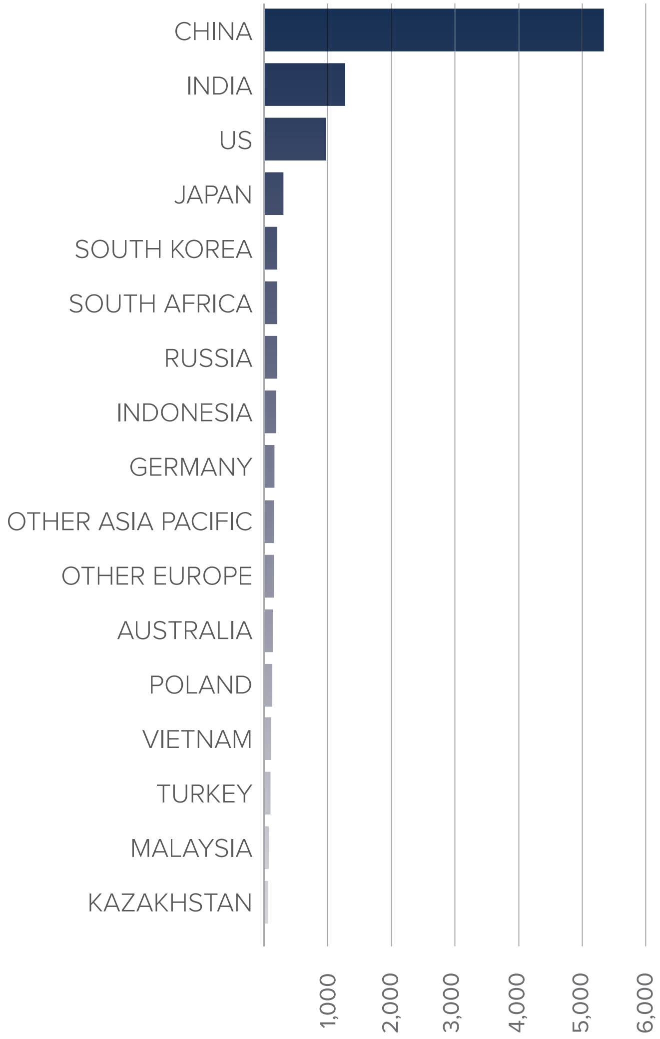
Increase of power production in 2021 (TWh)

Data Source: BP Statistical Review of World Energy 2022



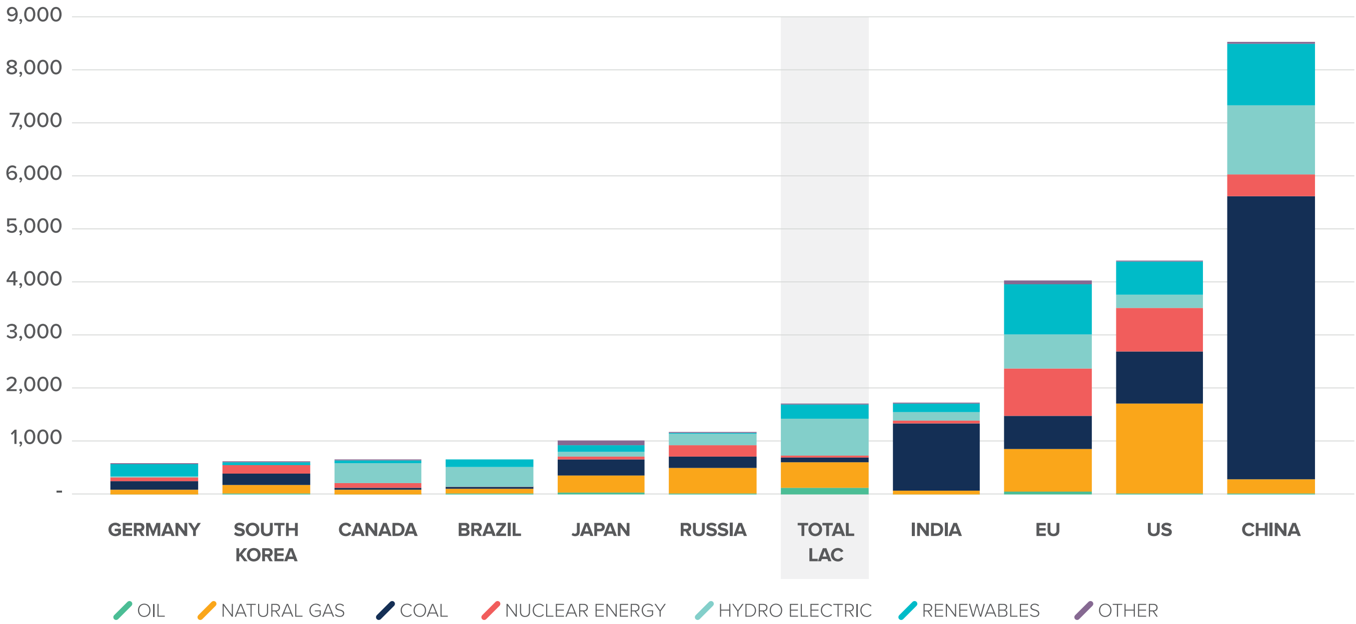
Coal generation production 2021 (>50 TWh)

Data Source: BP Statistical Review of World Energy 2022



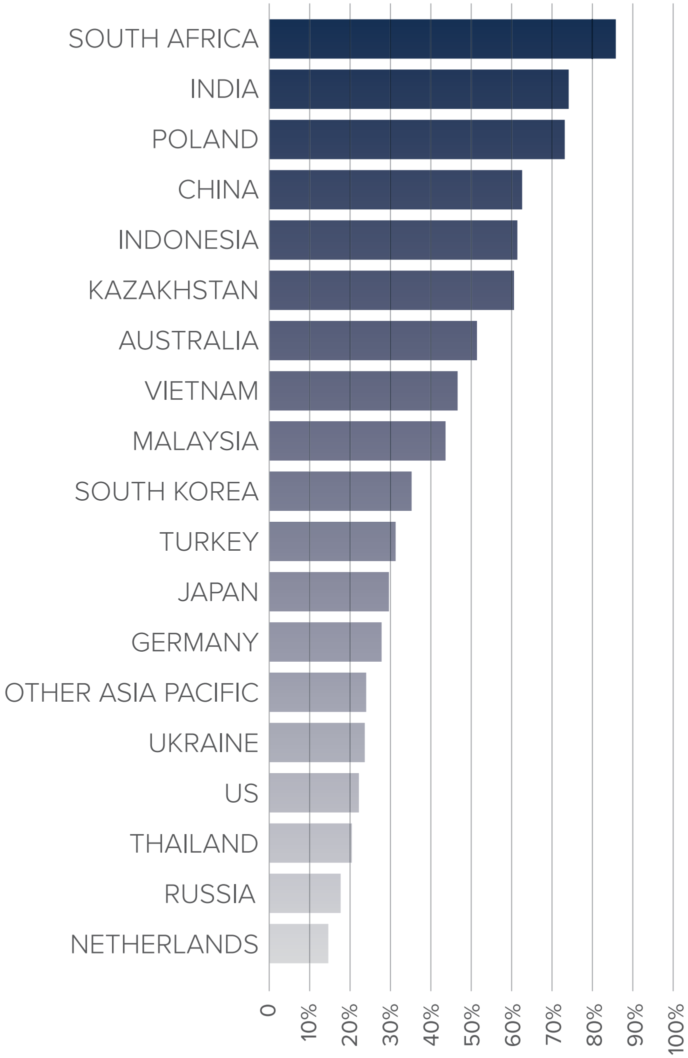
Power generation (TWh) 2021

Data Source: BP Statistical Review of World Energy 2022



Countries with electricity production coal generation > 15% mix

Data Source: BP Statistical Review of World Energy 2022



Power sector in Latin America and the Caribbean

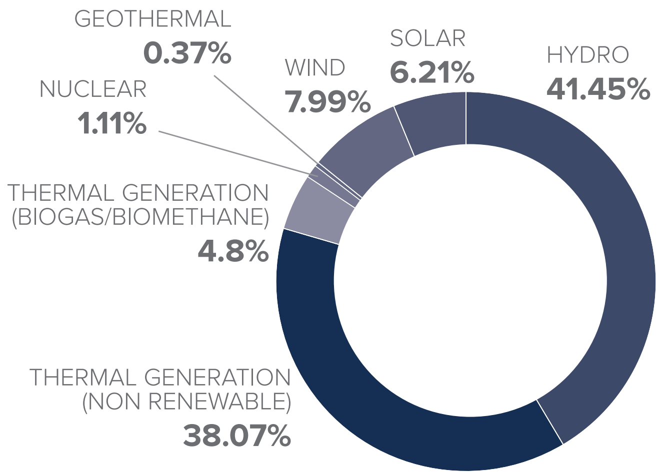
Latin America and the Caribbean sets the best example for energy transition in the power sector, representing the most decarbonized region in the world with the largest percentage of hydroelectric capacity in the electricity mix.

The installed capacity aggregates 481 GW with a high concentration of renewable resources. The reliability provided by the thermal power is based on natural gas, with the exception of Chile, which, despite having similar coal and gas capacity, has maximized coal generation until now.

The renewable generation production reached an average of 58% (2020 and 2021), with 27% of natural gas thermal generation production.[4]

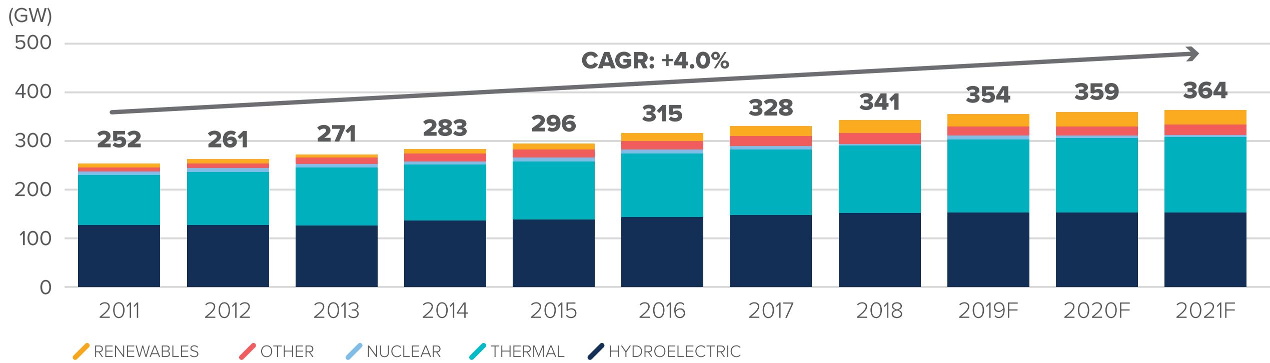
Installed capacity
%

Source: OLADE



Evolution of Installed Capacity

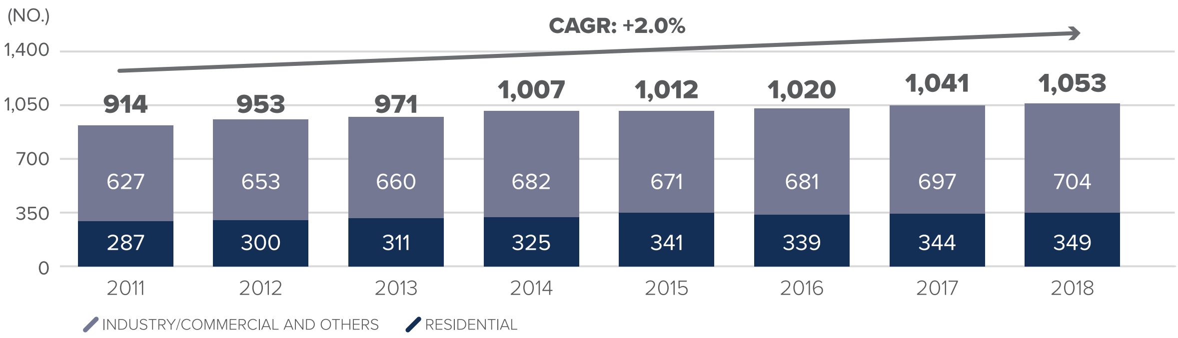
Source: Fitch Ratings, Regulatory Filings



[3] BP Statistical Review of World Energy, 2022.

Demand by Client Type

Source: Fitch Ratings, Regulatory Filings

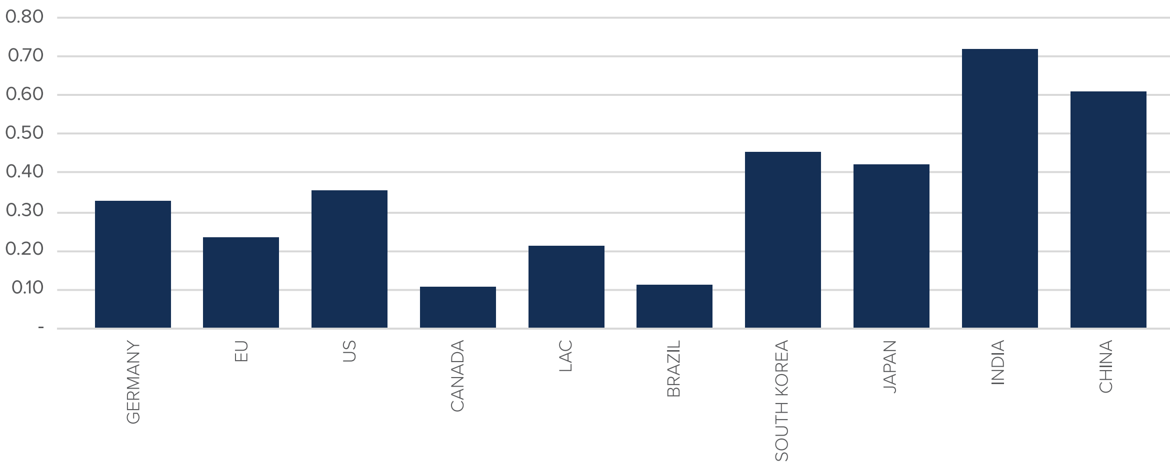


On the other hand, climate change poses a threat to hydroelectric production, mainly due to rising temperatures and the modification of rainfall patterns. By 2040, notwithstanding these risks, hydroelectric production is expected to maintain its contribution or even increase it in Latin America and the Caribbean, according to IEA[5], despite the requirements to modernize the installed capacity.

In the race to decarbonize the economies, the Latin America and the Caribbean base case is at the pole positon with the least carbon footprint in manufactured goods. Consequently, a rigorous accounting of emissions should benefit the region, once carbon border adjustment is on the agenda of several economies worldwide, such as the EU's recently announced levy on imports according to their carbon content.

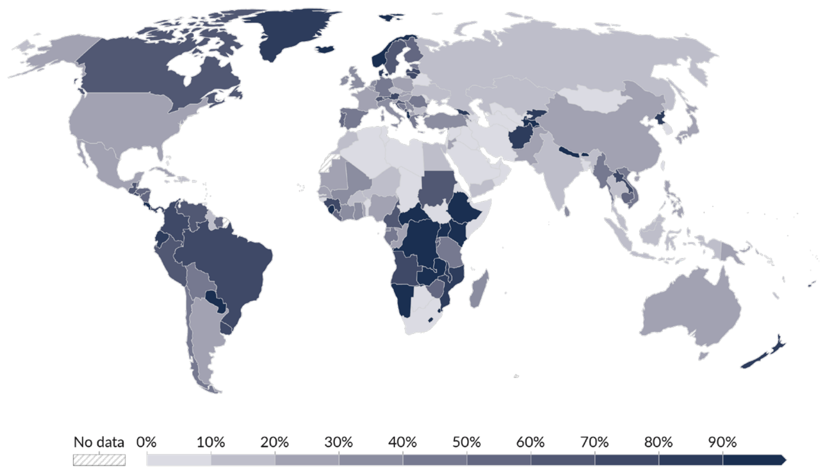
CO_2 emissions intensity (tCO2/KWh)

Source: Authors' calculation, based on BP Statistical Review of World Energy 2022[6]



Share of electricity production from renewables, 2022

Source: Our World in Data https://ourworldindata.org/grapher/share-electricity-renewables



[5] IEA, Climate Impacts on Latin America Hydropower, January 2021.
[6] Standard Emission coefficients for power plants: 0.37 GN, 0.77 FO-GO, 0.95 COAL (tCO2/kWh).

SECTION 4

Key Drivers for Natural Gas Development and Decarbonization

Hard-to-Abate Sectors

Transport

Transport is an essential economic activity that links production with consumption. All goods and services must be transported somehow to be delivered, and the high complexity of modern and globalized value chains puts transport at the center of the scene. Transport needs are on the rise; goods, services, and people move today more than ever before. Keeping the world moving needs a lot of energy.

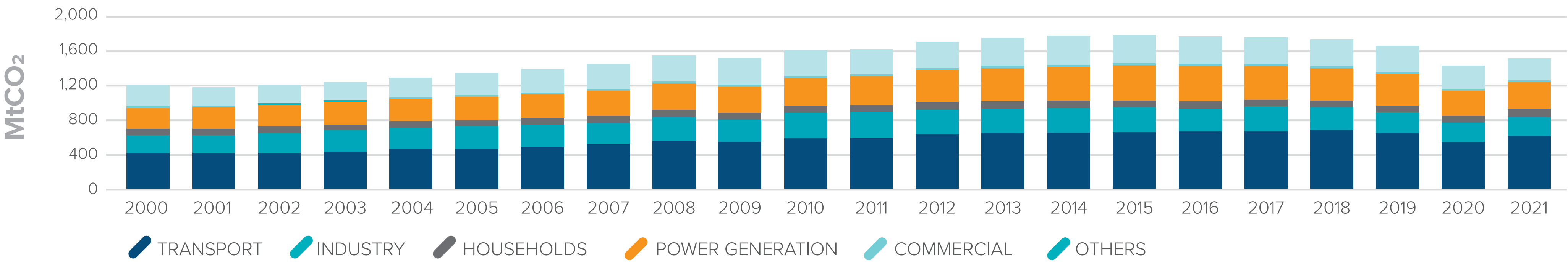
According to IEA[1], the total energy used in this sector is around 2,507 Mtoe, representing around 26% of the world's total energy demand. Approximately 90% of the energy used in the transport sector comes from oil products, 4% from biofuels (virtually all of them blended with oil products), 4% from natural gas, and 2% from electricity, which despite being growing at a great pace, still does not represent a high market share. Oil is king in the transport sector, and dominates the energy demand sector.

The transport sector's share of total world emissions is approximately 16%[2], and it accounted for 22% of global CO_2 emissions from energy in 2020[3], according to IEA[4]. Around three-quarters of that figure corresponds to road transport, while the rest is for aviation, maritime transport, rail, and others (IEA, 2022)[5]. In the Latin America and Caribbean region, because of its geography, and because of its economy, (which is primarily based on export of natural resources located inland at great distances from ports), transport's share of CO_2 emissions is much higher, at around 40%, approximately 600 Mt of CO_2[6]. In addition, the rail network is poorly developed, so the bulk of goods and people transport (around 85% of tonne-km — according to UNEP[7]) is carried out by trucks and buses fueled by inefficient and old diesel engines, with an emission factor of about 2.68 kg of CO_2 per liter. Because of this, mitigating emissions from the transport sector is a priority in many countries in the region.

For many reasons, transport could be considered a hard-to-abate sector not only because of technology availability and costs to substitute the current system but also because of the many actors and decisions involved at the international, national, sub-national, and individual levels. Transport is composed of diverse and very complex value chains, so many different solutions would have room to contribute to this problem, from natural gas (including biomethane) to hydrogen, electric vehicles, biofuels and synthetic fuels, or even shifting to active mobility (bicycles or walking), investing in more livable cities. However, modern life and cities have been built around cars for more than a century, so breaking this dependency is not an easy task; in the meantime, we will need all sources of energy capable of making transport more efficient and capable of reducing its emissions of GHGs and other pollutants, such as NOx, SOx, and particulate matter.

CO_2 Emissions Evolution in Latin America and the Caribbean by Sector

Source: OLADE[8]



[1] https://www.iea.org/sankey/#?c=World&s=Final%20consumption.
[2] Our world in data, Minx et al. 2022.
[3] 2020 is the last available data published by IEA (in 2022). It is supposed to be a little bit under the trend value due to Covid lockdowns in 2020.
[4] IEA, 2022, CO2 emissions from energy. Greenhouse Gas Emissions from Energy - Data product – IEA.
[5] IEA, 2022.
[6] OLADE, 2022 "Panorama energético de América Latina y Caribe".
[7] UNEP (2019). Zero Carbon Latin America and the Caribbean. https://www.unep.org/es/resources/informe/carbono-cero-america-latina-y-el-caribe
[8] https://www.olade.org/wp-content/uploads/2023/01/Panorama-ALC-13-12-2022.pdf.

Road Transport

Combustion of natural gas produces 27% fewer CO_2 emissions than diesel fuel on an energy equivalent basis; CNG in heavy-duty vehicles produces 13%-17% and LNG 6%-11% fewer GHG emissions than diesel on the well-to-wheel basis[9], while reducing NOx, SOx, and PM almost to zero.

The use of CNG[10] as a transport fuel is a mature technology that is widely used in parts of the world. CNG vehicles are as reliable as traditional diesel or gasoline vehicles[11]. CNG is a feasible option for city buses and even light-duty vehicles where natural gas is abundant. Some good examples can be found in the region in countries such as Argentina, Bolivia, Brazil, Colombia, or Peru. On the other hand, battery electric vehicles (BEVs) for light-duty transport are rapidly winning market share in Europe, China, and the USA. BEVs represented 9% of new vehicle sales in H_2 2021 and H1 2022, according to BNEF[12]. In the Latin America and Caribbean region, Chile and Uruguay, two oil importing countries, have been the most successful in introducing electric vehicles. However, BEVs face some challenges for scaling up in the region, as they are still expensive, there is limited recharging infrastructure, there are significant weaknesses in distribution grids, and some barriers to deploying investments in infrastructure can be found.

CNG is a feasible option for city buses and even light-duty vehicles where natural gas is abundant. Some good examples can be found in the region in countries such as Argentina, Bolivia, Brazil, Colombia, or Peru.

Heavy transport, where the great bulk of emissions come from, is much more challenging to electrify because energy density, weight, and load capacity are critical issues where batteries do not have their best performance. In the case of developing green hydrogen, while many countries have developed roadmaps and some projects are on track, technology and infrastructure are still immature, and scaling them up is expected to take a while. LNG could be a good option for heavy transport; however, while the technology can be considered mature, no refueling infrastructure has yet been developed in the region. The Blue Corridors project in Argentina, some virtual gas pipelines, and some experiences associated with LNG terminals could set the basis for development.

There is a massive amount of energy to be substituted, and the feasibility of each technology must be analyzed on a case-by-case basis, but there will undoubtedly be room for electricity, natural gas, hydrogen, and other solutions in this sector, including modal shifts. The advantage of natural gas as a transport fuel is that it is a mature and readily available technology and there is abundant experience of its use in the region. This can provide quick wins without generating lock-ins or stranded assets in this very complex sector.

[9] https://www.ngvamerica.org/wp-content/uploads/2018/03/NGVAmerica-White-Paper-Fleets-Run-Cleaner-on-Natural-Gas_V2.pdf.
[10] Natural gas compressed in tanks at 200 bar.
[11] https://www.ctc-n.org/technology-library/vehicle-and-fuel-technologies/compressed-natural-gas-cng-fuel
[12] https://about.bnef.com/blog/zero-emission-vehicles-progress-dashboard/.

Maritime Transport

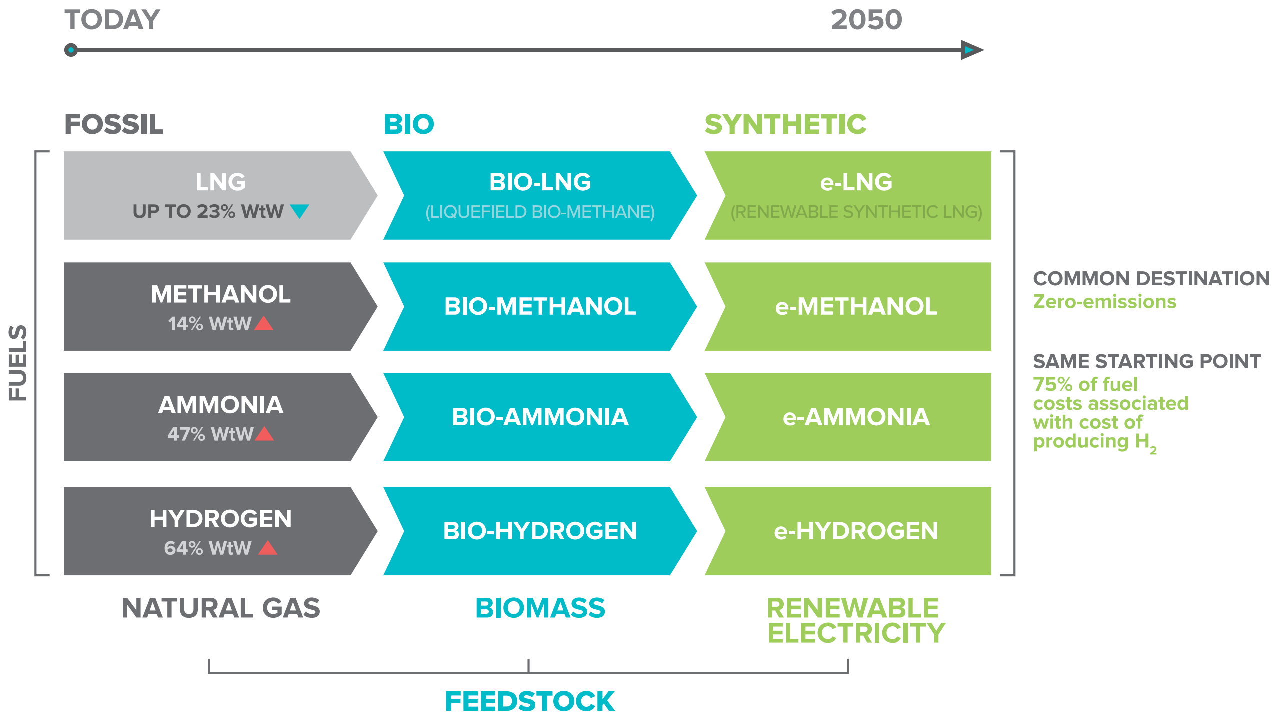
International maritime transport is a relatively concentrated market and has a leading organization capable of setting regulations and standards, IMO, which is the UN agency for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. This institutional framework and industry setting are very different from road transport, where many more players are involved, and progress is harder to induce.

In 2018, IMO set an initial strategy to decarbonize maritime transport. The objective was to cut annual GHG emissions from international shipping by at least half by 2050, compared with their level in 2008, and work towards phasing out GHG emissions from shipping entirely as soon as possible in this century[13].

LNG can reduce GHG emissions by more than 20% in bunker vessels in the short term with mature and safe technology that can pave the way to net-zero. Other technologies expected to have a role in the maritime transport sectors are still immature, and their current fossil-based versions (methanol, ammonia, and hydrogen) are worse than LNG. As highlighted by SEA-LNG, "fossil LNG offers significant GHG emissions reduction when used as a marine fuel compared with very low sulfur fuel oil (VLSFO) – up to 23% on a full lifecycle (well-to-wake). By contrast, the use of fossil methanol, ammonia, and (liquid) hydrogen results in emissions far higher than those associated with VLSFO because of the large amounts of fossil energy required for their production".

Maritime Transport Fuel Transition Pathway

Source: SEA-LNG. A view from the bridge. 2022-2023



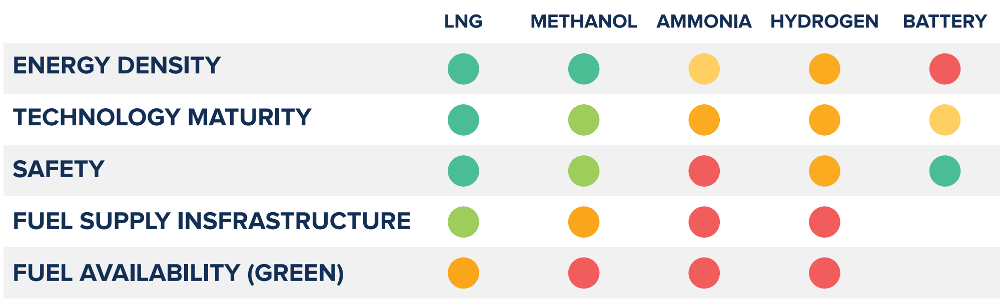
[13] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx.

Additionally in the same report SEA-LNG[14] points out that, “Discussion of alternative fuels too often compares the green versions of, for example, ammonia and methanol, with fossil, or grey, LNG. The reality is that all fuels share a common pathway from fossil-based versions, produced from natural gas (often in the form of LNG) to hydrogen-based, renewably produced synthetic fuels. These synthetic fuels will only become available as and when sufficient renewable electricity and electrolysis capacity comes online to produce them”.

All energy scenarios from the most reputable agencies expect LNG trade to grow in the future. Latin America and the Caribbean is no exception, as LNG terminals have recently been developed in many countries in the region. This presents an obvious opportunity for deploying LNG for bunkering. In addition, the strategic role of the Panama Canal, and concentrated maritime transport in the Caribbean, pose great opportunities for the region. While there has not been much progress in Latin America and the Caribbean, there is an existing and successful LNG for shipping example. The high-speed LNG ferry that links Buenos Aires and Montevideo across the River Plate —around 215 km — twice a day, with a capacity of around 1,000 people and 150 cars, began operations almost 10 years ago, substituting oil products and reducing emissions since then.

Maritime Transport Technology Review
by Feature

Source: SEA-LNG. A view from the bridge. 2022-2023



Industry

Energy use in the industrial sector accounts for 24% of the total world’s GHG emissions. Most of them correspond to iron and steel (7.2%) and chemical and petrochemicals (3.6%); two critical and energy-intensive industrial sectors. On the other hand, emissions from industrial processes — apart from energy use — account for 5% of the world’s total, where chemicals and cement are the most relevant sectors.

Iron, steel, cement, or chemicals are so embedded in almost every product that modern life would be impossible without them. These materials are the foundation of social and economic development, from construction to industrial machinery, electrical equipment, domestic appliances, fertilizers, or medicines. They are also critical for the energy transition; for example, an average wind turbine is comprised of 80% steel, used in the tower, nacelle, and rotor (IFC)[15]. A rapid energy transition puts pressure on these industries, and making them “greener” is also an essential part of the transformation.

However, the high temperatures needed for steel production (where fossil fuels typically perform better) and/or the very specific characteristics of industrial and chemical processes, makes it difficult to find cost-effective and efficient alternatives to reduce the carbon footprint of these industries. They are, in general, energy- and carbon-intensive and thus hard-to-abate sectors.

The industrial sector is very heterogeneous, and solutions are very sector specific. However, some

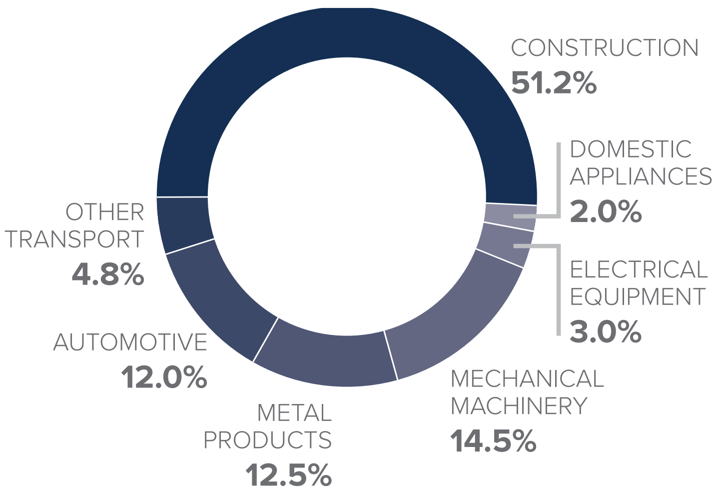
[14] SEA-LNG, A view from the bridge 2022-2023.
[15] Strengthening Sustainability in the Steel Industry
https://www.ifc.org/wps/wcm/connect/a3b90fed-c3bf-4b13-a186-a154a257ebaa/FINAL_IFC_Steel_7-26-2021.pdf?MOD=AJPERES&CVID=nldEffP

key recommendations apply across the board. For those energy-intensive industries where fossil fuels are still needed — mainly for heating — and natural gas is available, the direct substitution of coal, or oil products with gas brings advantages in terms of GHG emissions and other pollutants. When possible, changes in processes may apply. For instance, migration from blast/basic oxygen furnaces to Direct Reduced Iron (DRI) and Electric Arc Furnaces (EF), which mostly rely on natural gas, can cut emissions by more than two-thirds in the steel industry. However, this change is not always possible. In cement production, CCS has been identified as one promising alternative to reduce emissions. CCUS would also be key to reducing GHG emissions in hydrogen production from natural gas (blue hydrogen), essential to producing DRI -contributing to mitigation of emissions in the steel industry, fertilizers, methanol, and other chemicals.

Hard-to-abate sectors are very complex, not only because the intrinsic characteristics of their production processes make it difficult to cost-effectively mitigate emissions with current technologies, but also because most of them are absolutely essential to a decarbonized future. A systemic approach to this problem is needed, and natural gas is a critical element of the transformation process.

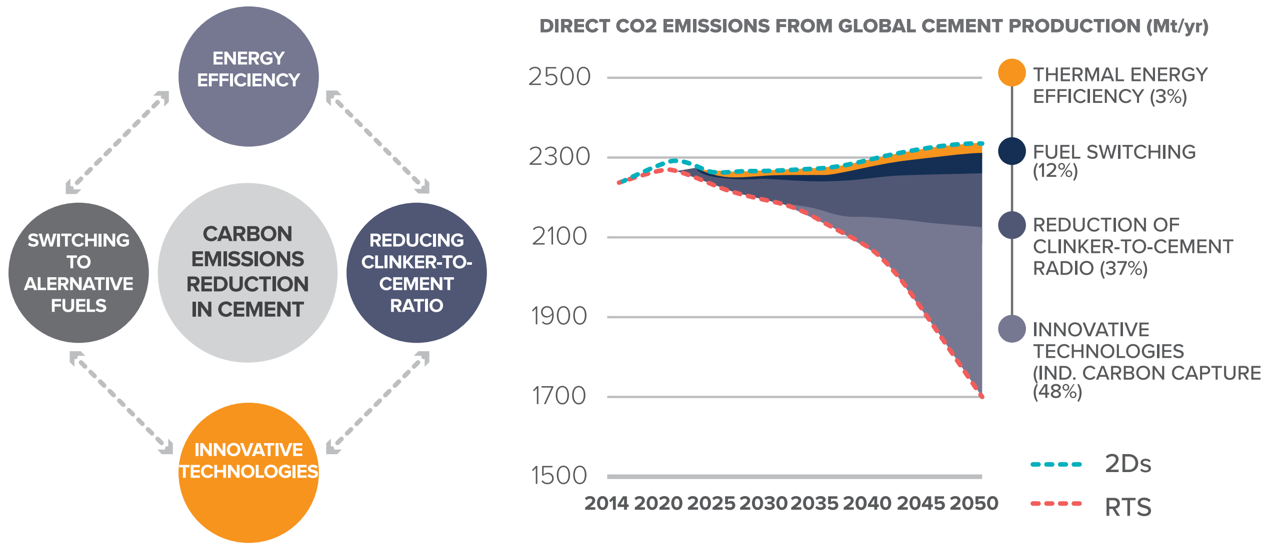
Steel's main uses
2011

Source: WORLD STEEL ASSOCIATON



Strategies to reduce CO_2 emissions from cement production

Source: IFC [16]



Carbon emissions reduction levers can influencethe potential for emissions reductions of the other options.
Reference: IEA - CSI, 2018

The equivalent of almost 90% of today's direct global industrial CO2 emissions are cumulatively avoided from cement production in the 2DS compared to RTS.

[16] Strengthening Sustainability in the Cement Industry
https://www.ifc.org/wps/wcm/connect/242c9ecd-3c4e-4201-839f-0f392a25b41b/IFC-StrengthingSustainability-Cement-WEB.pdf?MOD=AJPERES&CVID=nQGkUn7

SECTION 4

Key Drivers for Natural Gas Development and Decarbonization

Enabling low-carbon solutions

CCUS, Hydrogen, Fertilizers, Biogas, and Biomethane

Carbon capture and storage

Carbon capture and storage (CCS), is a term that refers to technologies that capture CO_2 and store it safely underground so that it does not contribute to climate change. If captured carbon is utilized in any other process, for instance, as a feedstock for producing synthetic fuels, then this is called Carbon capture, utilization, and storage (CCUS). Carbon capture includes both capturing CO_2 from large emission sources (referred to as point-source capture) and also directly from the atmosphere.

Point-source capture is when a large emission source, like an industrial facility, is equipped with technology allowing the capture and diversion to storage of CO_2, preventing it from being emitted. Removing historical CO_2 emissions already in the atmosphere through direct air capture and storage (DACCS) or bioenergy with capture and storage (BECCS) is possible.

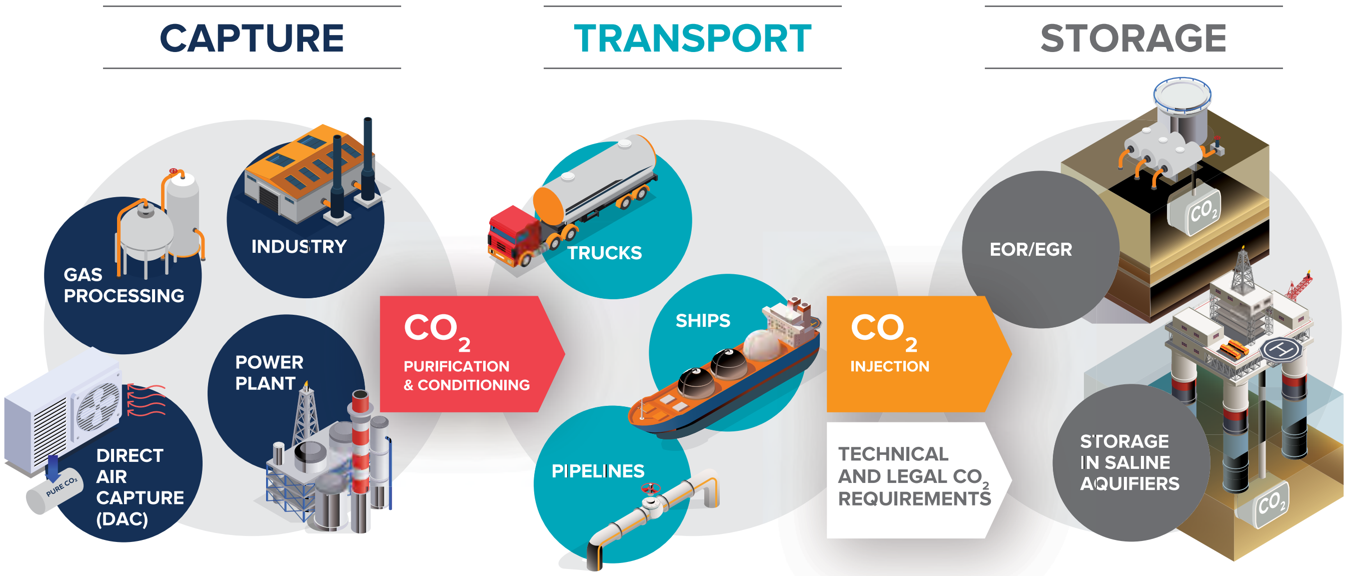
CCUS can be applied across sectors vital to our economy, including cement, steel, fertilizers, power generation, and natural gas processing, and can be used to produce clean hydrogen. CCUS-equipped power and industrial plants operating today are designed to capture around 90% of the CO_2 from flue gas (https://www.iea.org/reports/carbon-capture-utilisation-and-storage-2).

The oil and gas industry adopted CCS early, deploying the technology in the 1970s in North America. Most of these lower-cost opportunities are in gas processing. Natural gas reservoirs can contain impurities such as CO_2 or sulfur dioxide which need to be separated before the gas can be transported by pipelines or liquefied into LNG because of user specifications and as impurities may lead to corrosion. The separation process results in a very concentrated stream of CO_2 which is accessible to transport and store, making this one of the easiest and lowest-cost applications of CCS. As a result, up until the 2000s, nearly all the CO_2 captured globally at large-scale facilities came from gas processing.

From an environmental and climate perspective, CCS is a crucial mitigation tool for reaching carbon neutrality. There is an international agreement that CCS is vital for meeting global climate and energy goals. This fact is explicitly mentioned in IPCC's Eighth Assessment Report[2] and IEA's World Energy Outlook.

Carbon capture and storage - a conceptual diagram

Source: Global Carbon Capture Institute [1]



[1] https://www.globalccsinstitute.com/wp-content/uploads/2022/03/CCE-CCS-Technology-Readiness-and-Costs-22-1.pdf.
[2] https://www.globalccsinstitute.com/wp-content/uploads/2022/04/CCS-in-the-latest-IPCC-report-%E2%80%9CMitigation-of-Climate-Change%E2%80%9D-April-2022-1.pdf.

Costs of Carbon Capture

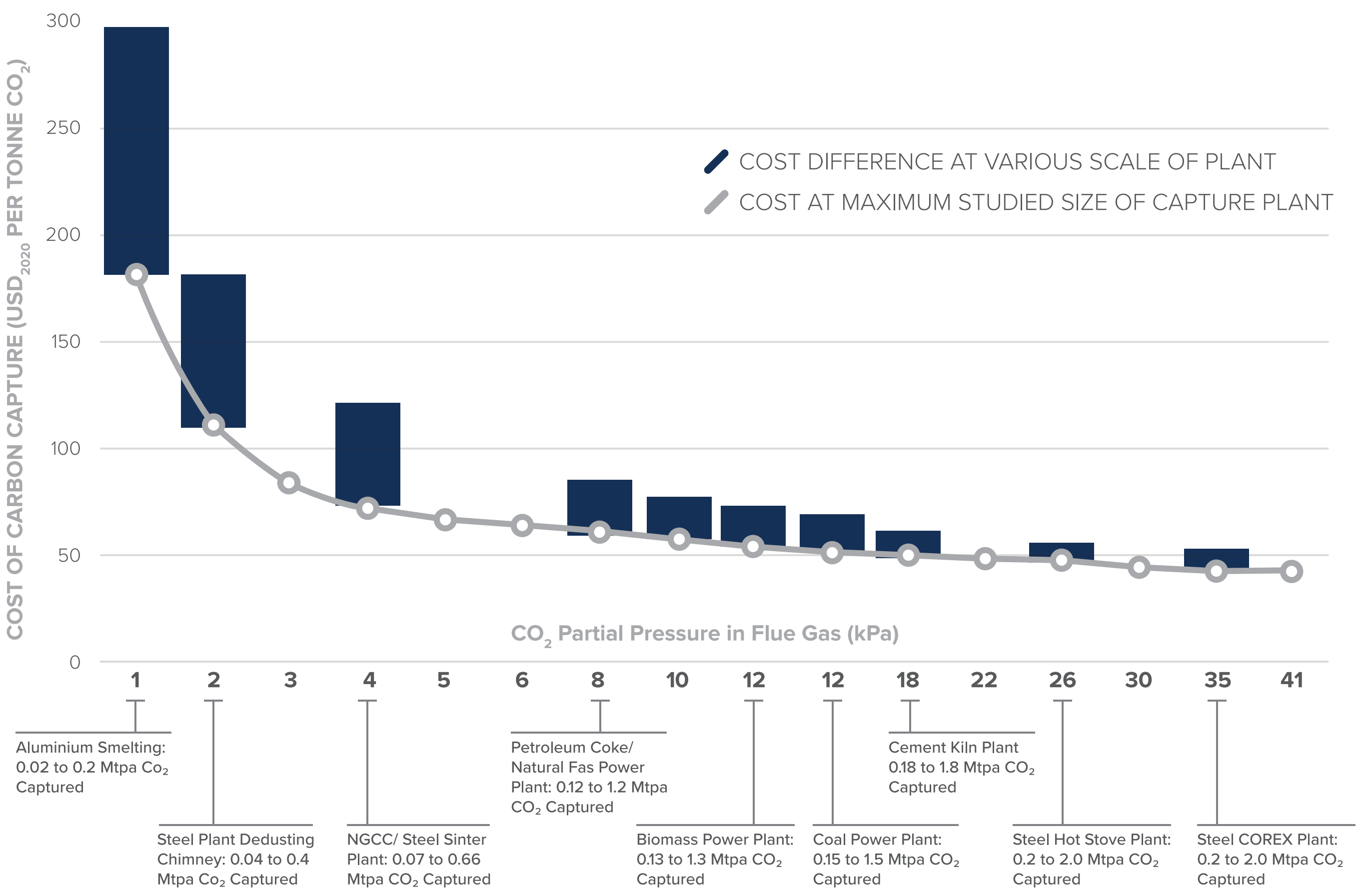
Point-source carbon capture costs depend mainly on two factors: partial pressure and scale. The partial pressure of CO_2 reflects the relative ease with which CO_2 can be captured from a gas mixture.

Higher partial pressures are easier and cheaper to capture than lower pressures because less external energy is required to increase the CO_2's partial pressure to that in the final captured CO_2 stream. Higher CO_2 partial pressures are observed when the fraction of CO_2 is higher, the overall gas pressure is higher, or both. The other main factor that drives the cost of capture is economies of scale. In most industrial processes, higher rates of production typically drive lower unit costs. Carbon capture is no exception.

Despite the benefits and flexibility, **Direct Air Capture** (DAC) is more costly per tonne of CO_2 removed compared to many mitigation approaches and natural climate solutions, as it is energy intensive to separate CO_2 from ambient air. The range of costs for DAC vary between US$250 and US$600[3] today depending on the technology choice, low-carbon energy source, and the scale of their deployment.

Impact of CO_2 partial pressure and scale on the cost of carbon capture

Source: Global Carbon Capture Institute



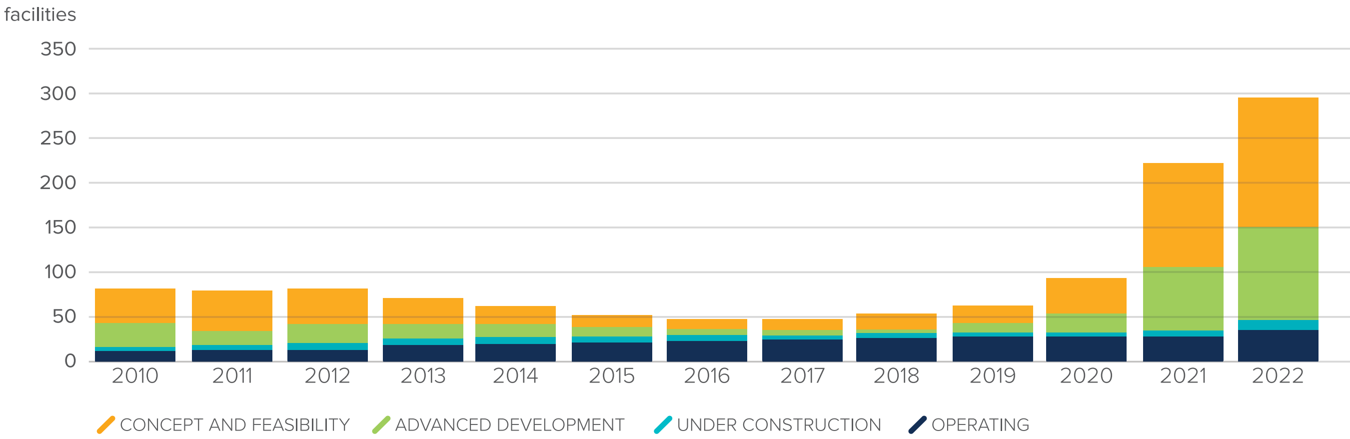
[3] https://www.wri.org/insights/direct-air-capture-resource-considerations-and-costs-carbon-removal#:~:text=The%20range%20of%20costs%20for,less%20than%20%2450%2Ftonne.

Global Overview

There are now around 35 commercial capture facilities in operation globally, with a total annual capture capacity of almost 45 Mt of CO_2. Since the start of 2018, momentum behind CCUS has been growing. Project developers have announced ambitions for over 200 new capture facilities to be operating by 2030, capturing over 220 Mt of CO_2 per year. However, only around 10 commercial capture projects under development have reached a final investment decision as of June 2022. While CCUS is a critical technology for decarbonization, its deployment needs to be accelerated and scaled-up. Current global rates of deployment are far below those in modeled pathways to limit global warming to 1.5°C or 2°C. CCUS implementation currently faces technological, economic, institutional, and ecological-environmental and socio-cultural barriers.

Evolution of the CO_2 capture project pipeline 2010-2022

Source: IEA https://www.iea.org/reports/carbon-capture-utilisation-and-storage-2



Americas Overview[4]

Three countries are leading the way in the Americas: Canada, the USA, and Brazil.

Canada's federal budget strongly supports CCUS via an investment tax credit. The tax credit rate is 60% for DAC projects, 50% for all other carbon capture projects, and 37.5% for transportation, storage, and use.

The **USA** enacted the historic Inflation Reduction Act of 2022, which includes US$369 billion in funding for climate energy. The Infrastructure Investment and Jobs Act includes over US$12 billion to be spent on CCUS over the next five years. The legislation includes funding for CCUS research, development, and demonstration, CO_2 transport and storage infrastructure, carbon utilization market development and four regional DACCS hubs, and a DAC Technology Competition.

Brazil hosts an operating CCS facility in the Santos Basin where Petrobras continues progressing toward its goal of injecting 40 Mt of CO_2 by 2025. Significant policy developments regarding CCS deployment occurred in 2021 and 2022 in Brazil. Bill 1.425/2022 establishes a legal framework for the geological storage of CO_2, addressing pore space property rights, long-term responsibilities and the transfer from private to public agent, the definition of regulatory agencies, and the period of monitoring.

CCS is an opportunity in Latin America and the Caribbean. Many countries, as detailed in the following chapters, have a long history of oil and gas production so depleted oil and gas fields could serve as storage sites for captured CO_2, helping to scale up this technology in the region.

[4] https://status22.globalccsinstitute.com/2022-status-report/regional-overview/.

CCS and ESG

Though the process is not developed, CCS has a role in ESG relative to managing climate risks and defining the opportunities and benefits afforded through this technology investment and deployment. The environmental pillar[5] includes consideration of a wide variety of factors, including, amongst others, emissions of CO_2 or CO_2 equivalents, energy and resource consumption, waste production, and water withdrawal and use. The “E” pillar ratings and disclosures are now being used by investors to understand how a company aims to align with a low-carbon economy, its low-carbon transition pathways, and material climate-related financial risks. This trend was highlighted in the 2021 letter[6] to CEOs from the chairman and CEO of BlackRock, the world’s largest investment manager, which stated that “no issue ranks higher than climate change on our clients’ lists of priorities”.

Recent analysis suggests[7] that investors and companies are reconsidering the “social” or “S” factor within their ESG assessments and disclosures. With the rise of socially conscious investment practices, CCS deployment will likely be seen as a necessary technology. With the introduction of new reporting regulatory requirements, monitoring, reporting, and verification requirements will prove to be important for accountability and transparency for ideally gaining increased investor and public acceptance of the deployment of this technology. The Covid-19 crisis revealed even to large investors the frailties and equities that result from systemic inequities[8]. Investors and financiers have indicated that they, too, will be increasingly considering companies’ “S” factor performance against issues as diverse as board representation, working conditions, and economic, gender, and racial equality. Governments worldwide have introduced post-Covid initiatives and support packages aimed at bolstering efforts around sustainability, many of which also seek to address the significant social factors exposed by the pandemic.

Governance encompasses management practices related to GHG emissions reductions, risk and risk assessments, and opportunities associated with the low-carbon transition and how companies’ carbon emissions compare with the international targets. Governance could also include visible expressions of commitment, such as a corporate governance statement outlining governance practices. CCS may be reported as an opportunity or as a control mechanism to mitigate climate risks. A developing focus[9] on deploying low-carbon technologies, further global commitments to reduce emissions, and the transition to a net-zero economy, will ultimately see investors pay increasing interest to technologies such as CCS and their potential. For o rganizations with a significant emissions footprint, there are no further essential considerations to be addressed when contemplating the role of CCS under reporting frameworks.

The Intergovernmental Panel on Climate Change (IPCC) working group III report on climate change mitigation identified carbon capture and storage (CCS) as a relevant technology to mitigate GHG emissions across the energy sector.

[5] https://www.globalccsinstitute.com/wp-content/uploads/2022/06/Thought-Leadership-ESG-Reporting-Methodology-to-Support-Investment.pdf.
[6] https://www.blackrock.com/us/individual/2021-larry-fink-ceo-letter.
[7] https://www.globalccsinstitute.com/wp-content/uploads/2022/06/Thought-Leadership-ESG-Reporting-Methodology-to-Support-Investment.pdf.
[8] https://www.blackrock.com/us/individual/2021-larry-fink-ceo-letter.
[9] https://www.globalccsinstitute.com/wp-content/uploads/2022/06/Thought-Leadership-ESG-Reporting-Methodology-to-Support-Investment.pdf.

Hydrogen

Latin America and the Caribbean is one of the leading regions for renewable energy globally and this puts the region in a favorable position for the deployment of new green, blue and turquoise hydrogen technologies. On the other hand, as of today, hydrogen demand is concentrated in the largest economies, and Trinidad & Tobago, accounts for more than 40% of total hydrogen demand for the chemical industry, being the world leader in methanol production. **Although current hydrogen production is grey, with natural gas steam reforming without CCS, the potential of including carbon capture, thanks to the depleted fields, opens a real opportunity to reduce CO_2 emissions, through the transformation of grey hydrogen into blue hydrogen.** Consequently, there are many conditions that could make the region a global leader in low-carbon hydrogen production and unlock international trade opportunities, both for hydrogen production or valorized products (chemicals, fertilizers, and bio-fuels) and uses in the refining processes.

As highlighted by IEA[10], low-carbon hydrogen will be crucial in a global net-zero emissions future and absolutely needed where electrification is not possible, like industrial applications (hard-to-abate) or transport, complementing other fuels and providing an alternative option in the coming years. **However, low-carbon hydrogen deployment is still at an early stage, with a "chicken and egg problem" between supply and demand, due to the lack of firm volumes on both sides of the value chain.** Additionally, some boundary conditions, such as the scarcity of CO_2 pricing schemes in some countries, and the "expectancy" of a drop in renewable power prices, are hindering some of today´s low-carbon hydrogen technologies, which could start with CO_2 reductions now.

The urgency to avert climate change[11] in the 2020s, must lead us to a pragmatic approach that maximizes all the available technologies today, and incentivizes new ones, with short-term and long-term signals, through the standardization of legal frameworks, with a low-carbon certification and guarantees of origin schemes, which assures no low-carbon technology is left out of the market.

The horizon is clear, and although scenarios could be diverse, there is a common forecast baseline that the role of hydrogen in final energy demand by 2050, will be close to 12%. (IEA and the International Renewable Energy Agency (IRENA) scenarios and those of other organizations estimate a range of between 6% and 25%[12] and that the expected demand will exceed 660 Mt by 2050[13]. On the other hand, Wood Mackenzie forecasts that the capital cost of hydrogen production will reduce significantly in the next 10 years, and major policy support for low-carbon hydrogen, like REPowerEU in the EU and the IRA in the USA, are fostering the escalation of new technologies and infrastructures. In addition, the geopolitics of hydrogen add new trade routes and agreement with new supply and demand options.

[10] IEA, Global Hydrogen Review 2022.
11 IPCC, "Special Report: Global Warming of 1.5 ºC: Summary for Policymakers" , October 2018, Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24. https://doi.org/10.1017/9781009157940.001.
[12] World Energy Council. "Hydrogen on the Horizon: ready, almost set, go? 2021".
[13] Hydrogen Council, "Global hydrogen flows", October 2022.

Hydrogen Demand Potential

Hydrogen[14] demand (90 Mt in 2020) was focused on refining processes, with 40 Mt (45% of global hydrogen demand), followed by industry feedstock, with ammonia (34 Mt) and methanol (15 Mt). Hydrogen demand in road transport increased 60% in 2021, from 20 Mt to 30 Mt, mainly for trucks and buses. On the other hand, in the future, according to the Hydrogen Council, “China, India, Japan, South Korea, Europe, and North America will account for 75% of global hydrogen demand, with China emerging as the largest consumer in the years to come”.

In this wide-ranging debate, there is a key fundamental discussion in some jurisdictions, around separating and identifying the hydrogen with low or zero emissions, sometimes misleadingly called renewable hydrogen. This conversation must guarantee to include all the technical alternatives, in a clear support to maximize innovation and efficiency, following an agnostic approach with no punitive regulations. As an example, the use of renewable energy is not restricted to green hydrogen production, as it is the cornerstone of turquoise hydrogen, as well.

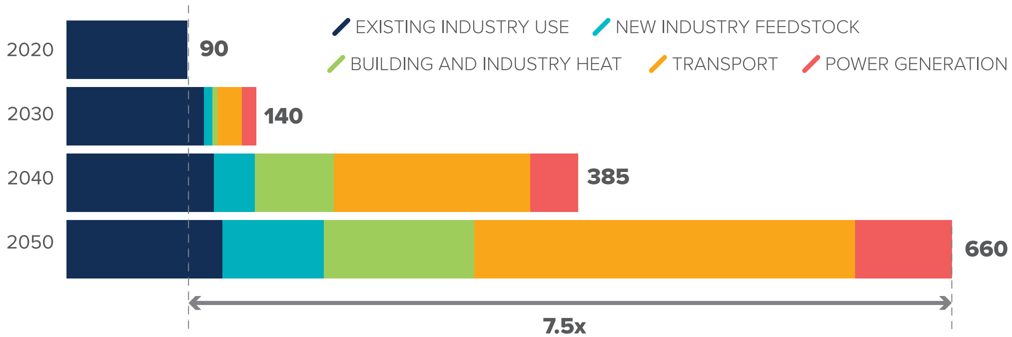
The potential prospect for hydrogen in decarbonization encompasses industrial sectors, from the use of hydrogen as a feedstock (chemical, fertilizer industry, and synthetic fuels) to a direct use of combustion fuel for industrial and process heating. Additionally, as of today, the technology of hydrogen and gas turbines is a reality, with a wide range of hydrogen concentrations (up to 100%), which means that in the future many CCGT plants could be consuming natural gas and hydrogen in different proportions, and keeping their key role as a back-up to renewable power generation.

On the other hand, as said before, the use of hydrogen in some industrial sectors is not new, which reinforces the relevance of future competition between current uses and new ones. It is worth mentioning, at this stage, **that today hydrogen is a key feedstock for half of existing production of fertilizers, and in the future, hydrogen will be also a key feedstock for synthetic fuels production, essential in many transport sectors. Additionally, the Hydrogen Council expects that transport will be the main hydrogen offtaker, thorough direct or indirect use with synthetic fuels. So, adopting an agnostic approach towards hydrogen is set to benefit citizens with affordable energy, food, and fuels.**

Nevertheless, the growth of low-carbon and zero-hydrogen across many sectors is still facing many barriers, such as the deployment of large-scale dedicated infrastructure in many regions, connecting production hubs with offtakers, lack of incentives for companies and safety concerns, and by and large, the necessity that the levelized cost of hydrogen is reduced significantly.

Hydrogen demand potential by sector
million tons

Source: Hydrogen for net-zero. Hydrogen Council. Nov. 2021



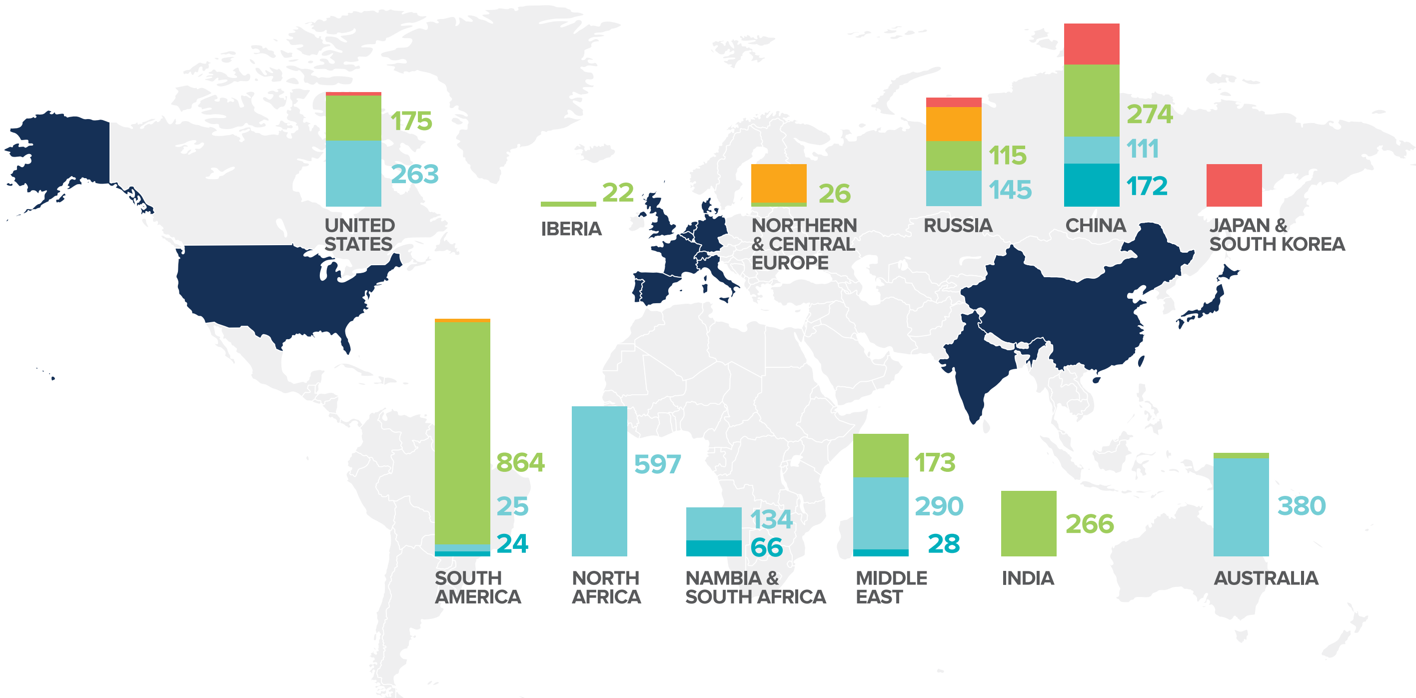
[14] IEA, Global Hydrogen Review, 2022.

Hydrogen Supply Potential

The production costs and commercial potential for each region vary widely, and competitiveness is mainly driven by the levelized cost of hydrogen production, and some country factors, such as country-risk factor, market efficiency, and workforce availability.

Hydrogen production potential
2050 - million tons per annum

Source: Hydrogen Council 2022



Cost of production $/kg	Cost category implications
>2.5	Production is uncompetitive versus imports
1.80-2.50	Pipeline imports are preferred over local production, but importing pure hydrogen via ship is still not worthwhile
1.20-1.80	Production costs are good enough to produce for local pure hydrogen demand, but derivatives are likely imported
1.00 - 1.20	Completitive for exports to proximate markets
<1.00	Competitive for exports to any market
DEMAND CENTER	

Hydrogen Policies in Latin America and The Caribbean

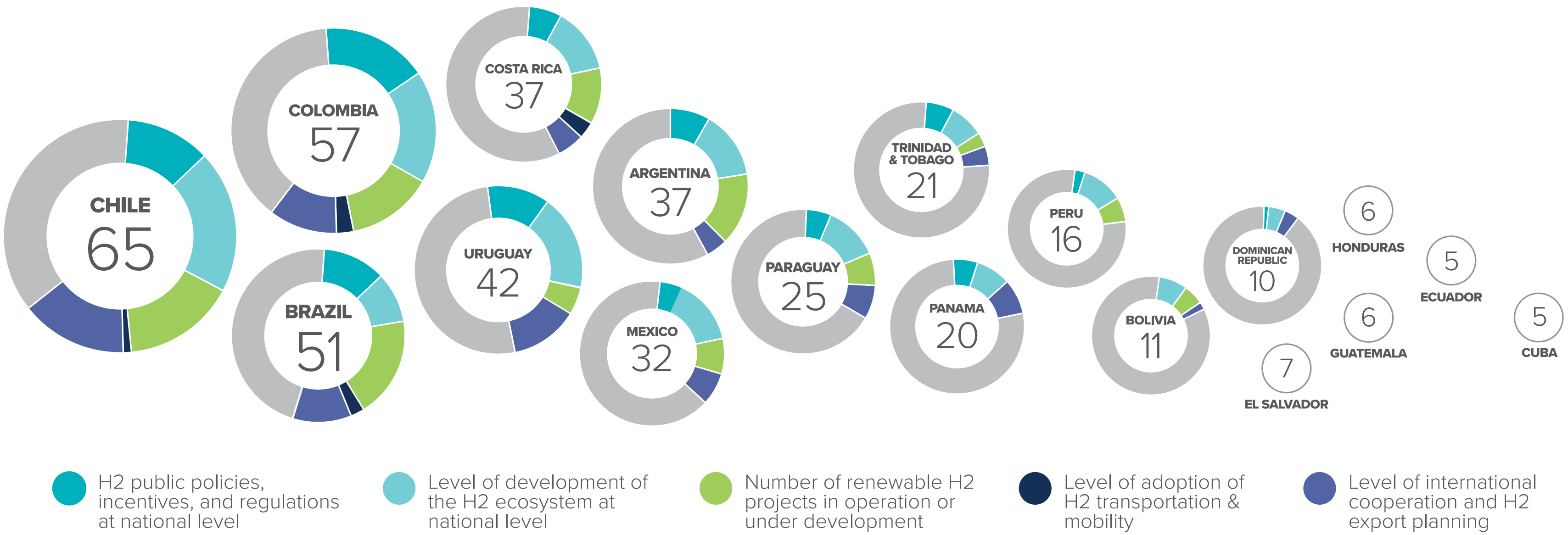
The Hydrogen Index for Latin America and the Caribbean (2022 H_2LAC INDEX), published by HINICIO and New Energy materializes a test for hydrogen policies, state of art in technology and international cooperation. The document highlights the policies of Chile, Colombia, and Brazil, as the first three Latin American countries in hydrogen development.

Some of the KPIs that were included in the analysis are:

- Regulation on hydrogen as an energy vector;
- Public financial incentives for project development;
- National decarbonization plans and strategies that include hydrogen;
- Benefits, tax advantages for the adoption of hydrogen;
- Regulatory and safety frameworks for handling;
- Certification schemes and guarantees of origin;
- Normative and regulatory framework for uses;
- Production methods included in the sustainability strategies;
- Studies and forecast of hydrogen implementation and opportunities;
- R&D funds from the public sector focused on hydrogen;
- National associations or trade associations focused on hydrogen;
- Development of workforce capabilities;
- National events focused on hydrogen.

H2LAC Index 2022

Source: HINICIO and Newenergy



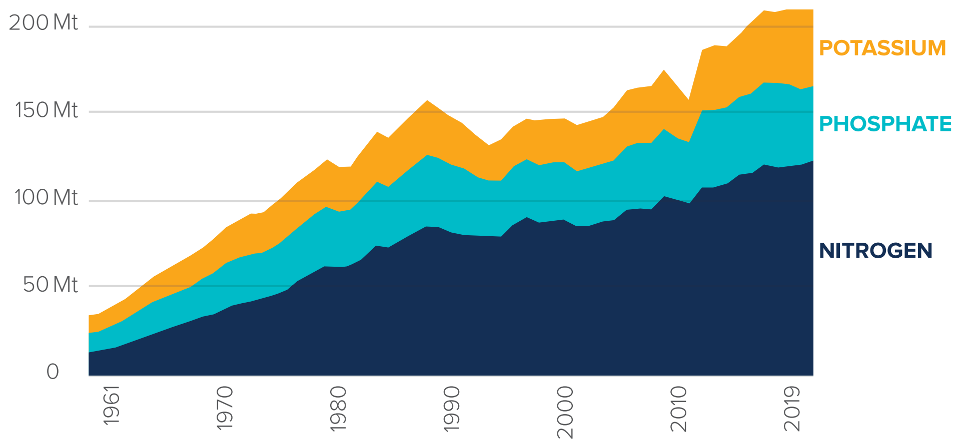
Fertilizers: The challenge of decarbonizing fertilizers and food security

The relevance of ammonia

As a result of the application of fertilizers to crops, productivity[15] in agriculture has improved, allowing more people to gain access to food and improving its affordability, even under the current population growth trend. Furthermore, the expected increase of 2 billion people in the next 25 years (doubling the growth rate), means that 60% more food must be produced in the same land area[16] to supply the population. As of today, nitrogen fertilizers represent 59% of total fertilizer production, followed by phosphate and potassium, representing 21% and 20% respectively)[17].

Fertilizer production by nutrient type
World, 1961 to 2019

Source: Our World in Data
https://www.fao.org/faostat/en/#data



Ammonia is a fundamental product for the fertilizer industry, as a raw material for nitrogen fertilizers and at least 50% of global food production today is possible because of synthetic nitrogen fertilizers.

NITROGEN
Nitrogen is primarily responsible for vegetative growth. Nitrogen assimilation into amino acids is the building block for protein in the plant. It is a component of chlorophyll and is required for several enzyme reactions.

PHOSPHORUS
Phosphorus is a major component in plant DNA and RNA. Phosphorus is also critical in root development, crop maturity, and seed production.

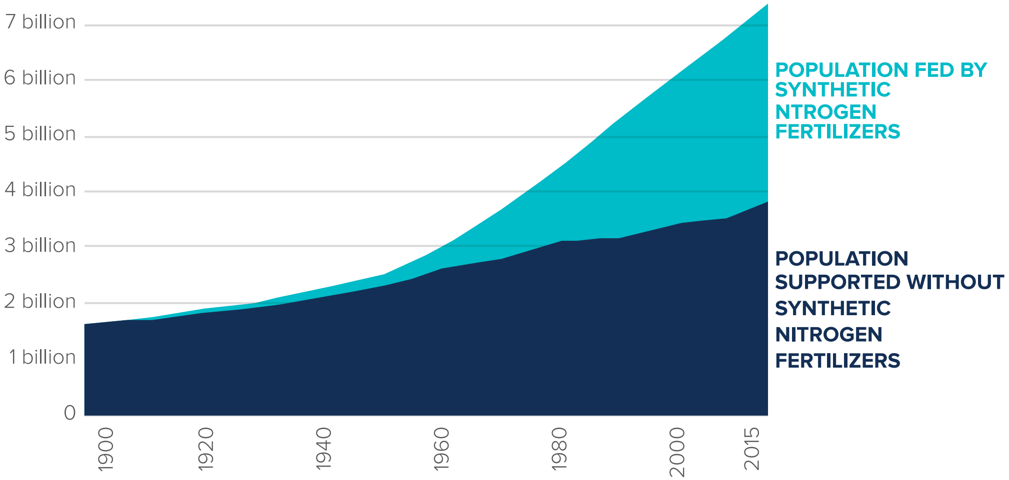
POTASSIUM
The role of potassium in the plant is indirect, meaning that it does not make up any plant part. Potassium is required for the activation of over 80 enzymes throughout the plant. It is important for a plant's ability to withstand extreme cold and hot temperatures, drought, and pests. Potassium increases water use efficiency and transforms sugars to starch in the grain-filling process

Source: Noble Research Institute[18]

[15] https://www.ers.usda.gov/data-products/international-agricultural-productivity.
[16] https://www.yara.com/crop-nutrition/crop-and-agronomy-knowledge/why-is-fertilizer-important/.
[17] Our World in Data, FAO — Food and Agriculture Organization of the United Nations: World fertilizer production 209.5 Mt (123 Mt nitrogen, 43 Mt phosphate and 44 Mt potassium).
[18] The Noble Research Institute is the largest nonprofit agricultural research organization in the USA.

Fertilizer production by nutrient type
World, 1961 to 2019, Tonnes

Source: Our World in Data
Article: Nature Geoscience https://www.nature.com/articles/ngeo325



GREY AMMONIA
(conventional ammonia)

The hydrogen is produced through the Steam Reformation of Methane, a process that emits CO_2

BLUE AMMONIA
(conventional ammonia)

The hydrogen is produced through the Steam Reformation of Methane, but CO_2 is stored using CCS.

GREEN AMMONIA

Made with hydrogen that comes from Water Electrolysis powered by renewable energy.
(If the power energy is supplied directly from the grid, and it is not certified 100% renewable, it is called yellow ammonia)

TURQUOISE AMMONIA

Through Pyrolysis of Methane, with the result of hydrogen and pure carbon.

In terms of energy consumption and carbon intensity, today's production of nitrogen fertilizers is energy intensive, with ammonia production mainly based on natural gas as feedstock (other options include coal and oil) with Steam Methane Reforming as the most common technology, without carbon capture. Average world production emits 12 kg of CO_2 per kg of hydrogen and if the feedstock is natural gas, the emissions are in the range of 9.5 kg of CO_2 per kg of hydrogen[19].

Following hydrogen terminology, the ammonia industry has a similarly labeled color description, representing different methods of ammonia production. The main industrial ammonia production processes are through the Haber-Bosch process, with the reaction of hydrogen and atmospheric nitrogen.

Grey, green and blue hydrogen utilize water in the processes as feedstock. This could be a challenge in some areas with hydric stress[20], representing a key element for industry decision-making under a likely incremental hydric scarcity, due to climate change[21]. Turquoise ammonia, through its different processes (thermal decomposition, plasma decomposition, and catalytic decomposition)[22], opens a promising alternative[23] with zero emissions (if natural gas is the feedstock) or negative carbon emissions (providing a blending feedstock of natural gas and biogas). Additionally, the latest publications demonstrate a good alternative in terms of energy consumption, compared to green hydrogen, and administrations in some countries, like the USA[24], have started to offer clear finance support for project escalation and commercialization.

[19] "Methane pyrolysis: The third way for low CO2 hydrogen production", Laurent Fulcheri, MINES-ParisTech.
[20] IMF, Hydrogen's Decade, December 2022. Thijs Van de Graaf, Professor at Ghent University, Lead author IRENA report "Geopolitics of the Energy Transformation The Hydrogen Factor".
[21] Council of Foreign Relations, https://www.cfr.org/backgrounder/water-stress-global-problem-thats-getting-worse.
[22] "State of the Art of Hydrogen Production via Pyrolysis of Natural Gas", ChemBioEne (Stefan Schneider, Siegfried Bajohr, Frank Graf, Thomas Kolb), July. 2020.
[23] "Why turquoise hydrogen will be a game changer for energy transition", International Journal of Hydrogen Energy, July 2022, Jad Diab, Laurent Fulcheri, Volker Hessel, Vandad Rohani, Michael Frenklach.
[24] DOE Loan Programs Office, US Energy.gov: https://www.energy.gov/lpo/articles/open-business-lpo-issues-new-conditional-commitment-loan-guarantee.

Methane pyrolysis
(Turquoise Hydrogen)
25 kWh/kg of hydrogen

Water Electrolysis
(Green Hydrogen)
60 kWh/kg of hydrogen[25]

(real-time operation data from the first commercial plant utilizing this process)

Currently, there are calls for a Sustainable Hydrogen Strategy, prioritizing technologies that reduce the amount of consumed energy per tonne of saved CO_2[26], like methane pyrolysis. However, **the challenge of decarbonizing the fertilizer industry[27], as well as the basic necessity of food security in the coming decades, is so relevant that policymakers should maximize all the best options known today, with the least carbon-footprint; fostering the scalability and bankability of new projects (like turquoise and green), as well as the feasibility of retrofitting current grey processes for blue hydrogen with carbon capture. Openness to all low carbon hydrogen technologies is the only way to assure affordable food.**

The role of natural gas in hydrogen production (turquoise and blue) and ammonia production is essential in the fertilizer industry, and the roadmap to follow implies moving from grey to other alternatives the sooner the better.

Other options, like pink hydrogen (generated through electrolysis powered by nuclear energy), may also result in a good choice, provided the Treaty[28] on the Non-proliferation of Nuclear Weapons is ratified, where according to Article 3, each non-nuclear weapon state party to the Treaty should conclude a safeguards agreement with the International Atomic Energy Authority to prohibit the diversion of nuclear materials from peaceful to non-peaceful uses.

UREA[29]

The challenge to the nitrogen fertilizer industry is not only constrained to the technology of hydrogen production, but also to the share of urea in nitrogen fertilizers, representing 48%. Due to the CO_2 emissions when the urea decomposes in contact with acid soil, urea is termed a non-carbon-free product, and it is the only fertilizer that emits this gas.

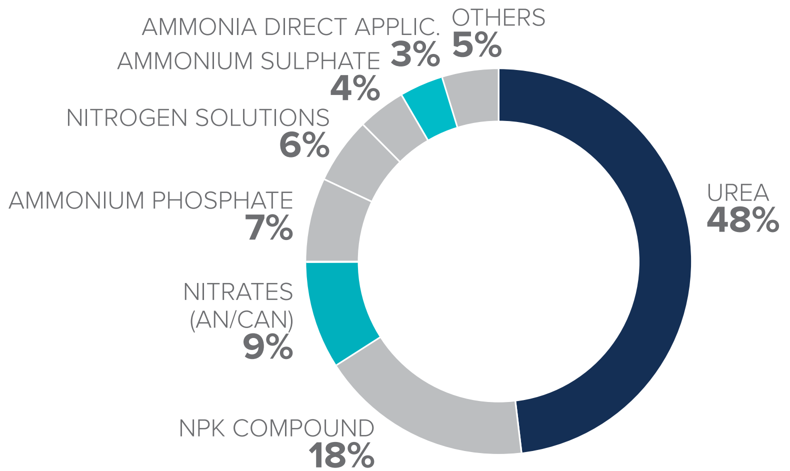
Acid soil: $CO(NH_2)2 + 2H+ + 2H_2O \longleftrightarrow 2NH_4 + + H_2O + CO_2$

Neutral soil: $CO(NH_2)2 + H + + 2H_2O \longleftrightarrow 2NH_4 + + HCO_3 -$

The rest of nitrogen fertilizers do not emit CO_2 in contact with the soil. And IPCC only separates CO_2 emissions of urea decomposition.

Global nitrogen fertilizer consumption by product
2018

Source: Argus



[25] "An energy-efficient plasma methane pyrolysis process for high yields of carbon black and hydrogen", Laurent Fulcheri, Vandad-Julien Rohani, Elliott Wyse, Ned Hardman, Enoch Dames, 26 January 2023, International Journal of Hydrogen Energy, Science Direct.
[26] BASF, "Methane Pyrolysis The solution to CO2-free Hydrogen and High Purity Carbon", Detlef Kratz, March 2021.
[27] "Challenge of greening agri-food system is 'absolutely massive', industry says", EUROACTIVE.
[28] https://www.iaea.org/sites/default/files/publications/documents/infcircs/1970/infcirc140.pdf.
[29] "Decarbonising the fertilizer industry: is green ammonia the answer or should we focus elsewhere?", ARGUS, May 2021.

Biogas and biomethane potential

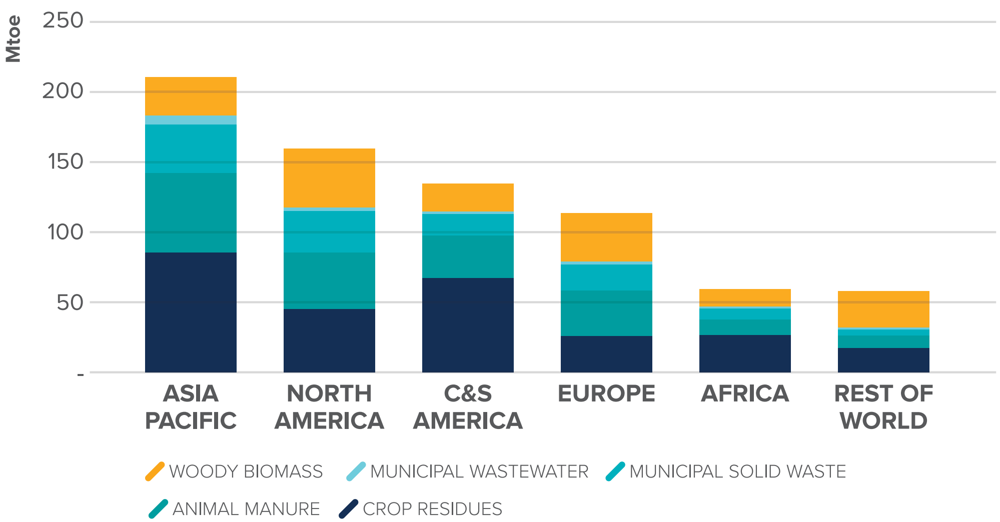
Biogas and biomethane production can enhance the development of the circular economy, where cities and villages are at the forefront of improving the wellbeing of their citizens via waste treatment; or utilizing residues of the agriculture sector.

Managing organic residues (bio-waste and wastewater) from industries and households, in the context of a growing population, is a challenging task, but avoiding emissions that otherwise would be produced by the decomposition of organic matter is a sufficient incentive to create the regulatory and economic conditions that can make it a reality. The improvement of waste collection programs, as well as public information campaigns to encourage the separation of residues, are also crucial for the success of biogas and biomethane. Latin America and the Caribbean, with 81% of its population living in urban areas, has four of the world's largest megacities: Mexico City, Mexico; São Paulo, Brazil; Buenos Aires, Argentina; and Rio de Janeiro, Brazil[30]. Other cities also exceed 5 million people: Bogota, Colombia; Lima, Peru; Santiago, Chile; Belo Horizonte, Brazil; Guadalajara, Mexico; and Monterrey, Mexico.

On the other hand, raising livestock is one of the most important economic activities in many countries in the region, with consequent methane emissions from the agricultural sector having a high share of total GHG emissions in those countries. Biomethane could be an alternative for reducing methane emissions.

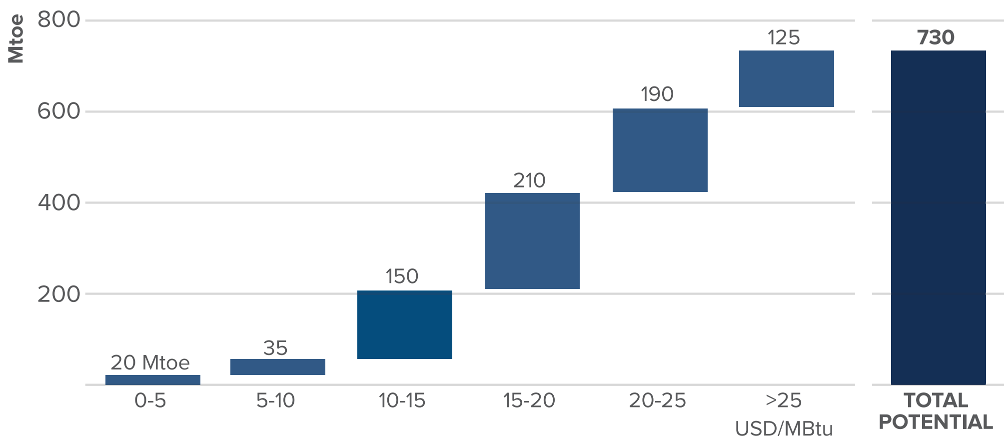
Poduction potential for biogas or biomethane by feedstock source, 2018

Source: IEA https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth



Cost ranges for developing global biomethane potential today

Source: IEA https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth



[31] UN-Habitat (2022; p.14): World Cities Report 2022. ISBN (serie): 978-92-1-133395-4. Disponible en: https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf

IGU defines biogas and biomethane as follows:

Biogas (or "raw biogas"):

A mixture of gases, predominantly methane and CO_2 produced by anaerobic digestion of biomass (typically agricultural waste, manure, sewage, and municipal waste). This process makes use of methane that would have otherwise been released into the atmosphere; hence, it has a direct GHG offsetting value.

Biogas is especially relevant where access to the natural gas grid is more challenging, in smaller or more isolated communities, and reduces the use of biomass and wood as cooking fuels, improving home air quality, with a direct positive effect for the most vulnerable societies.

Biomethane (or renewable natural gas):

Raw biogas from anaerobic digestion which has been upgraded to remove CO_2 and other impurities such that it is of a comparable quality to natural gas – thus it can be used as a direct supplement/substitute for natural gas in existing infrastructure and equipment. Biomethane can also be manufactured from woody biomass in a thermal gasification process, although this is much less common than production via anaerobic digestion.

Additionally, **e-methane or synthetic natural gas** describes the methane produced using renewable energy and CO_2.

Both biomethane and e-methane, thanks to their composition, are interchangeable with natural gas in all applications. Consequently, as the deployment of biomethane progresses, it can use existing gas infrastructure, such as transport pipelines, and fuel CCGT plants along with natural gas.

Policymakers are giving an impetus with clear objectives for biogas and biomethane production in the coming years. One example is the EU´s action plan, REPowerEU, with a goal of 35 bcm/year in 2030. And IEA, in the Sustainable Development Scenario, expects 200 million people to be using biogas for cooking by 2040, with the half in Africa, as forecasts in its publication "Outlook for biogas and biomethane: Prospects for organic growth".

Recognition of the avoided emissions, through different methodologies, is essential to the incorporation of biomethane into the gas grid, making it more competitive and improving the decarbonization of the natural gas mix. Regarding biomethane potential and development in the region, Brazil stands out (see chapter). However, there are many other countries showing a very good potential for biomethane. There is a lot of accumulated experience in the world, especially in OECD countries and China that can be brought to the region to accelerate progress in this area.

SECTION 4

Key Drivers for Natural Gas Development and Decarbonization

Other Key Strategic Issues

Energy Security,
Regional Integration and
ESG Performance

Energy security

Energy security landscape

The concept of energy security remained off the international political agenda for a long time, as high investments, supply, and trade met demand growth and flexibility requirements.

The IEA[1] defines energy security as **"the uninterrupted availability of energy sources at an affordable price".** This extended concept, shared by OLADE, ARPEL and the IGU, has two different horizons, with regard to the ability to foresee and avoid energy curtailments, and manage investment signals in the short term and mid-to-long term.

As of today, the issue of energy security is at the top of the policy agenda due to the direct impact on economies of the rise and volatility in the prices of hydrocarbons and key materials. (After the 2020 collapse due to the pandemic, the strong policy action against hydrocarbons investment, and exacerbated with the Russia-Ukraine conflict). Considering the greater uncertainty about long-term evolution of the energy supply and demand dynamics, it is worth noting the relevance of policy decisions and targets in providing signals to market players, which not only affect energy security but overall economic growth as well.

The essential role of energy, and the geostrategic implication of the whole value chain also related to other materials (metals and minerals) open a new period, where energy security, decarbonization, and affordability, are transversal concepts to energy and finance stakeholders.

Additionally, for energy security to be achieved, we must consider the need to guarantee energy flows to consumers, at reasonable costs and in a continuous manner, acknowledging that energy evolution (or "transitions") have so far been driven by market and technological developments rather than by political decisions. The optimal pathway to low-carbon economies implies a balanced mix of natural gas, low-carbon gases, synthetic fuels and renewable energy.

In a more interrelated energy and trade environment, it is therefore paramount to keep energy security among the top priorities in countries and/or regions, possibly combining the full deployment of domestic resources while also promoting cooperation to reduce potential impacts of energy crises as they can significantly affect – as witnessed in 2022 – not only the energy sector but large parts of the economy. Additionally, population growth is an important factor. Developed countries today have 200 million more inhabitants than 30 years ago, while the developing countries have more than 2.150 billion. As for GDP, developed countries accounted for two-thirds of the global total in the mid-1980s, while today they only account for half.[2]

[1] IEA, https://www.iea.org/topics/energy-security,
[2] IMF, World Economic Perspectives 2022.

Elements of energy security

Energy security has many aspects. Long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance[3].

Based on Elkind, former Assistant Secretary for International Energy Policy at the US Department of Energy, in order to have a complete definition of energy security, four essential aspects must be highlighted[4]:

1

AVAILABILITY:

To talk about a secure supply of energy, it is important to determine its availability, regarding the sources of supply — domestic or foreign — and, in the latter case, to consider geopolitical issues that could disrupt the continuous supply of an energy source.

2

RELIABILITY:

In order to be reliable, the sources of energy must be diversified, not only from a geographical point of view but also from a technological one. A reliable strategy is to develop domestic energy resources, diversifying foreign supply sources, as well as promoting energy efficiency and creating stocks to deal with emergency situations.

3

REASONABLE PRICES:

For a secure supply, prices must avoid situations of volatility that harm both the producer and the consumer. The prices of energy affect all the prices of any economy, as energy is an input to produce any good or service. Distributional effects of price volatility are not neutral, most likely affecting the poor. Energy supply and demand should evolve together to avoid imbalance and volatility; this means carrying out timely investments to supply energy in line with demand growth.

4

SUSTAINABILITY:

This encompasses environmental considerations. Any energy supply security policy should make every effort to sustain a secure supply avoiding the use of environmentally harmful energy sources and technologies. Likewise, the construction of infrastructure that may become obsolete in the medium and long term should be minimized. Comprehensive energy planning that considers bottlenecks in the value chain is needed to achieve this, as excessively forcing accelerating the transition could bring unintended consequences regarding sustainability.

[3] https://www.iea.org/topics/energy-security.
[4] Elkind, Jonathan and Pascual, Carlos, Energy Security, Washington DC: The Brookings Institution, 2011, pp 121-130.

The role of natural gas in international energy security

The world is still heavily dependent on the consumption of hydrocarbons. According to BP, in 2022, more than 80% of the total energy supply came from these sources[5]. In 1973, before the oil shocks, that figure was 87%, meaning that in the last 40 years the energy supply has diversified very little and, in recent years, pressure on resources has spread to emerging countries, when before it was only exerted on the central economies. In almost the same time horizon, total energy final consumption has doubled[6]; and it continues to grow at great pace, driven by population growth and economic development, mainly in emerging economies.

Natural gas is still the least consumed hydrocarbon. In the past, it was traded regionally, although it is becoming a commodity, mainly thanks to LNG trading. Gas accounts for almost 22% of global energy consumption and is the fastest growing fossil energy source. From an energy security perspective, natural gas resources are relatively widespread across the globe, allowing buyers to diversify geographical sources. Russia and the countries of Central Asia together with the Middle East are the regions with the greatest natural gas endowment, while the USA – largely benefiting from the technological upscale deriving from shale gas – has been the largest producer for some years now.

Developing natural gas resources and LNG infrastructure could help to increase energy security worldwide and sustain economic growth in emerging economies that would otherwise rely on more polluting fuels, such as coal.

The IEA's guidelines for secure energy transitions[7]

Last year, the IEA in its flagship publication proposed a 10-point list of guidelines for a secure energy transition. This comprehensive proposal deals with all energy sources, addresses challenges like the need for more investments (as point 1 should be read, considering that fossil fuels will be needed under any scenario) and intends to leave no-one behind the evolving energy landscape.

1. Synchronize scaling up a range of clean energy technologies with scaling back of fossil fuels.
2. Tackle the demand side and prioritise energy efficiency.
3. Reverse the slide into energy poverty and give poor communities a lift into the new energy economy.
4. Collaborate to bring down the cost of capital in emerging markets and developing economies.
5. Manage the retirement and reuse of existing infrastructure carefully, some of it will be essential for a secure journey to net zero.
6. Tackle the specific risks facing producer economies.
7. Invest in flexibility, a new watchword for electricity security.
8. Ensure diverse and resilient clean energy supply chains.
9. Foster the climate resilience of energy infrastructure.
10. Provide strategic direction and address market failures, but do not dismantle markets.

Even though the IEA guidelines tend to link moving away from fossil fuels and the increase in energy security, they also express two important things.

a) Natural gas producing economies can best support a "Just Transition" considering that moving away from fossil fuels will not guarantee per se the immediate, complete, and successful reallocation of resources, above all human resources, from the traditional energy sector to the renewable energy sector;

b) Investing in flexibility for fostering electricity security requires a consistent support for more natural gas (or LNG) in the electricity system worldwide and in Latin America and the Caribbean, too.

[5] BP Statistical Review of World Energy 2022.
[6] https://www.iea.org/data-and-statistics/charts/world-total-final-consumption-by-source-1973-2018.
[7] IEA, World Energy Outlook 2022.

The role of natural gas in Latin America and the Caribbean energy security

Domestic resources shield the region from international prices crisis

The international natural gas prices crisis in 2021-2022 had a limited direct impact on most countries of the region, as natural gas demand is mainly supplied with domestic resources or on long-term contracts, so countries were not highly exposed to international gas price volatility. This is the case of self-sufficient countries with abundant resources such as Trinidad & Tobago, Peru, Bolivia, or Colombia; while countries exposed to imports were more affected. However, the crisis mostly affected the region by other means, such as the increased cost of and shortage of fertilizers, and international inflation of food and other essential goods.

Natural gas and LNG provide flexibility to back up variable power supply

Power supply in Latin America and the Caribbean is dominated by hydropower, while other intermittent renewable energy sources play a key role in some countries. Hydropower production depends on water availability, which has marked seasonal variations and recurrent droughts in the region and may be severely affected by climate change in the medium term. Other intermittent renewable energy sources need rapid-response back-up.

Natural gas and LNG help to provide flexibility to power supply, backing up the development of hydropower and intermittent renewable energy sources. This is the case in countries like Brazil, where LNG was key during the last severe drought in 2021 and helped the country to avoid load-shedding measures; or in Colombia where it provides back-up to hydrological volatility mainly caused by recurrent El Niño climate phenomena. Understanding the critical role natural gas plays regarding power supply flexibility in the region is key to developing comprehensive energy planning.

Regional integration and LNG

Regional integration and LNG play a critical role in providing energy security, as they diversify supply sources. LNG, and mainly FSRUs, offer great flexibility. They serve as a back-up for the power sector and also for seasonal peak-shaving, as in Argentina where winter peak demand is covered.

Natural gas is critical for energy security in Latin America and the Caribbean, and this has significant impacts in the wider economy.

Continuing the development of domestic natural gas resources, transport infrastructure, industrialization, and regional integration could help the economies of Latin America and the Caribbean to avoid exposure to price volatility risks and supply disruptions, while contributing to international energy security.

Regional Integration

Introduction

For many countries in Latin America and the Caribbean, natural gas is a fundamental fuel and regional energy integration helps to strengthen regional energy security, promote economic development in producing countries, and diversify sources of supply in importing countries, helping to make natural gas more affordable and optimizing gas flows. While there is prolific experience of regional integration in the power sector in Latin America and the Caribbean, in the case of natural gas, regional integration has been mainly focused in the Southern Cone through bilateral agreements. However, changing dynamics regarding resources location, infrastructure development under a cost-benefit approach, and new supply-demand patterns have created increasing complementarities among countries, opening new scenarios for greater regional integration.

As of today, one of the bottlenecks to overcome is related to the lack of a regional market that allows the transit of gas from one country to another, with compatible legal, commercial, and physical standards and frameworks. Additionally, there is also the question of gas infrastructure that enhances the interconnectivity of production and demand poles. Existing gas pipelines and projects under consideration can play a vital role in supporting the energy transition, as catalysts for the development of hydrogen, biogas and biomethane, another function that reduces any risk of "stranded assets" and assures the amortization of infrastructures.

A system of gas pipelines connected across a regional market, with a modern and harmonized regulatory scheme, will allow an increase in regional exchanges of gas, enhance the security of supply, and allow future consideration of shared capacities for the construction of LNG facilities, positioning the region as a gas exporter to an international market that is eager to have new suppliers.

In particular, OLADE seeks to advance actions aimed at deepening energy integration in its member countries using natural gas as a transition fuel. The objective of this line of action is to lay the foundations for discussion within OLADE, with all those countries interested, on the possibility of moving forward with a gas integration initiative in our region (or sub-regions) similar to those that exist in electricity as SIESUR[1], SINEA[2] or SIEPAC[3].

This chapter provides an analysis of four emerging poles for regional integration: Southern Cone, Northern South America, Mexico-USA, and LNG as a new means for integration.

[1] SIESUR Sistema de Integración Energética del Sur (South Energy Integration System)
[2] SINEA Sistema de Interconexión Eléctrica Andina (Andean Electrical Interconnection System)
[3] SIEPAC Sistema de Interconexión Eléctrica de los Países de América Central (Central American Electrical Interconnection System)

Southern Cone

Regional natural gas integration in the Southern Cone began effectively in the 1990s when most of the infrastructure was built and gas started to flow across borders. Fifteen pipelines were built to send gas from Bolivia to Brazil and Argentina; and from Argentina to Chile, Uruguay, and Brazil (see map page 90). Since then, and as very well-known, the dynamics of natural gas flows have changed more than once, leaving infrastructure highly underutilized, in particular because of the decline of production from gas fields in Argentina in the 2000s. This made it impossible to sustain supply, and triggered the development of LNG terminals in Chile and Argentina, and it was also a key driver of the energy transition in the power sector in Uruguay. However, one of the key advantages for this sub-region is that the most difficult step for integration, building infrastructure, has already been taken.

In the last decade, new opportunities for regional integration have appeared because of new complementarities and imbalances. Vaca Muerta boosted Argentina's gas availability, allowing the resumption of exports to Chile (during the warm season) and new thinking around the development of new regional and international markets. Bolivia entered a period of slowing production[4], with less export potential. Exports to Argentina and Brazil peaked in 2014 at 49 Mm3/d decreasing to 29 Mm3/d in 2022 (sources: Enargas/ANP). Finally, Brazil opened its gas market and it has a massive demand potential, reshaping the advantages of regional integration, trade agreements, and infrastructures.

Some new opportunities in the Southern Cone include:

Argentina-Brazil:
A direct route from Vaca Muerta to the Argentine-Brazilian border; and extending the Uruguaiana pipeline to Porto Alegre;

Argentina-Bolivia-Brazil:
Sending natural gas from Vaca Muerta to Brazil through Bolivia;

Argentina-Chile:
Vaca Muerta's gas could accelerate Chile's coal phase-out.

These options would expand markets for Argentina, open an opportunity for Bolivia to monetize its infrastructure, and allow Brazilian consumers in the south to access more affordable and secure gas supplies.

At the same time, the aforementioned options require investment to expand transport infrastructure from Vaca Muerta to the north of Argentina. To this end, Argentina is building the first stage of the Néstor Kirchner gas pipeline (see the Argentina chapter) and carrying out other minor interventions to reverse gas flows, among others.

The *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES) — Brazilian Development Bank committed US$689 million, and CAF US$540 million to fund pipeline infrastructure in Argentina.

[4] Production. BP Statistical Review of World Energy, 2022.

Political convergence

2023 seems to be a year where there is a political convergence with regard to energy security and integration. The 7th Summit of Heads of Government of CELAC, the Community of Latin American and Caribbean States, was held in Buenos Aires in January 2023, and there was alignment between leaders to "invigorate regional energy integration processes and carry out the Energy Transition through a broad consensus, under the political and regulatory leadership of governments and based on fruitful national dialogues with society and the private sector"[5].

Likewise, the Heads of Government of CELAC committed themselves to "Promote regional energy integration initiatives, as well as to identify new projects for electrical interconnection and hydrocarbon integration and other types of energy resources, with a view to making full use of the complementarities of the different resources of each country and the strengthening of regional energy security"[6].

In the past, there have been cooperation initiatives such as MERCOSUR Sub-group No. 9 or the UNASUR Energy Expert Group, dependent on the South American Energy Council, which discussed for years the possibility of establishing a regional energy market (electricity and natural gas).

After the visit of the President of Brazil to Argentina in January 2023, a broad cooperation agreement was signed between the two countries that involves the construction of infrastructure projects to link the unconventional gas produced in Vaca Muerta with Brazil's southeastern market. The countries "Determined the formation of a Working Group coordinated by high authorities of both countries to deepen the discussions on bilateral energy integration, including the natural gas market and the possibilities of joint development of the sector"[7]. In addition, "They agreed to strengthen the MERCOSUR[8] Energy Sub-group (SGT-9), seeking to promote synergies with SIESUR and promote other initiatives related to gas integration and new technologies, which could support SGT-9 with elements related to the design of energy exchange policies in the short and long term, including tax aspects and support mechanisms in critical operating conditions"[9].

These works would allow a greater volume of Argentine natural gas exports to Brazil and Chile and, in the medium term, begin to reduce Argentine imports of LNG.

[5] Special Declaration on Regional Energy Integration of CELAC countries, Buenos Aires, 24 January 2023.
[6] Ibid 4.
[7] Joint Declaration on the occasion of the official visit to the Argentine Republic of the President of the Federative Republic of Brazil, Luis Inácio Lula Da Silva. Buenos Aires, 23 January 2023.
[8] The Southern Common Market (MERCOSUR from its Spanish initials) is a regional integration process, initially established by Argentina, Brazil, Paraguay, and Uruguay, and subsequently joined by Venezuela and Bolivia* — the latter still complying with the accession procedure.
[9] Ibid. 6.

Regulatory Schemes

Building a regional market requires political will and the participation of numerous players: National states (including autonomous regulators and parliaments), producers, carriers, distributors, marketers, and electric generators, among others, must come together in a series of consensuses and agreements that allow the launch of this initiative.

Regional markets must be based on a regulatory convergence that allows the operation of the network in a harmonious manner. The purpose of the convergence is to reduce uncertainty and balance the principles of priority of internal supply, which producers always argue for, with that of security of supply, which importers emphasize. The establishment of an "Early Warning" mechanism against supply disturbances would bring predictability to the countries and would allow better planning of supply and demand by the Member States.

Likewise, a review of the current regulatory schemes would be necessary in order to promote the integration and active participation of production companies. Brazil, for example, has modified its legislation to encourage the participation of the private sector in the commercialization and transportation of natural gas and, according to EPE (2022), an investment of BRL 20.5 billion (US$4 billion) in the sector is expected over the forthcoming years[10]."

South America Natural Gas Pipelines International Connections

Source: ECLAC

Transport Capcity
Million m³/d

1	Punta Ballenas	CO	VE	Lago Maracaibo	13
2	San Matías	BO	BR	Cuiaba	2.5
3	Mutún	BO	BR	Corumba	30.8
4	Juana Azurdiy, Madrejones	BO	AR	Campo Grande	13.5
5	Pocitos	BO	AR	Campo Durán	7.4
6	Madrejones	BO	AR	Campo Durán	4.3
7	Aldea Brasilera	AR	BR	Uruguaiana	2.8
8	Petrouruguay, Colón	AR	UY	Paysandú	1
9	Cruz del Sur, Punta Lara	AR	UY	Montevideo	6
10	Norandino, Pichanal	AR	CH	Crucero	7.1
11	Atacama, Coronel Cornejo	AR	CH	Mejillones	8.5
12	GasAndes, Santiago	CH	AR	La Mora	9
13	Gas Pacífico, Loma La Plata	AR	CH	Las Mercedes	9.7
14	El Cóndor	AR	CH	Poseción	2
15	Cabo Vírgenes	AR	CH	Dungeness	1.3
16	San Sebastián	AR	CH	Bandurrias	2

AR: Argentina
BO: Bolivia
BR: Brazil
CH: Chile
CO: Colombia
UY: Uruguay
VE: Venezuela

[10] Brazil Ministry of Mining and Energy, Empresa de Pesquisa Energetica, Plano Indicativo de Gasodutos de Transporte 2022, Brasília: MME/EPE, 2022.

Northern South America

Trinidad & Tobago became the first exporting country in the region, when Atlantic LNG started operations in 1999. With a liquefaction capacity of 14.8 Mtpa, the country is also one of the main producers of the region. However, in the last few years natural gas production has been declining, from 40 Bcm at its peak in 2010 to 25 Bcm in 2021, leaving spare liquefaction capacity.

However, the prolific offshore gas field, Campo Dragón, located in neighboring Venezuela, can help Trinidad & Tobago to mitigate the gas production deficit. The proximity of this gas reserve and the capacity of Trinidad & Tobago to serve as an offtaker to export LNG or industrialize natural gas, creates obvious synergies between the two countries. Formal negotiations between Venezuela and Trinidad & Tobago are expected to take place in 2023, after the US government issued a grant to advance the project.

Additionally, the reactivation of the gas pipeline between Colombia and Venezuela opens up future market integration.

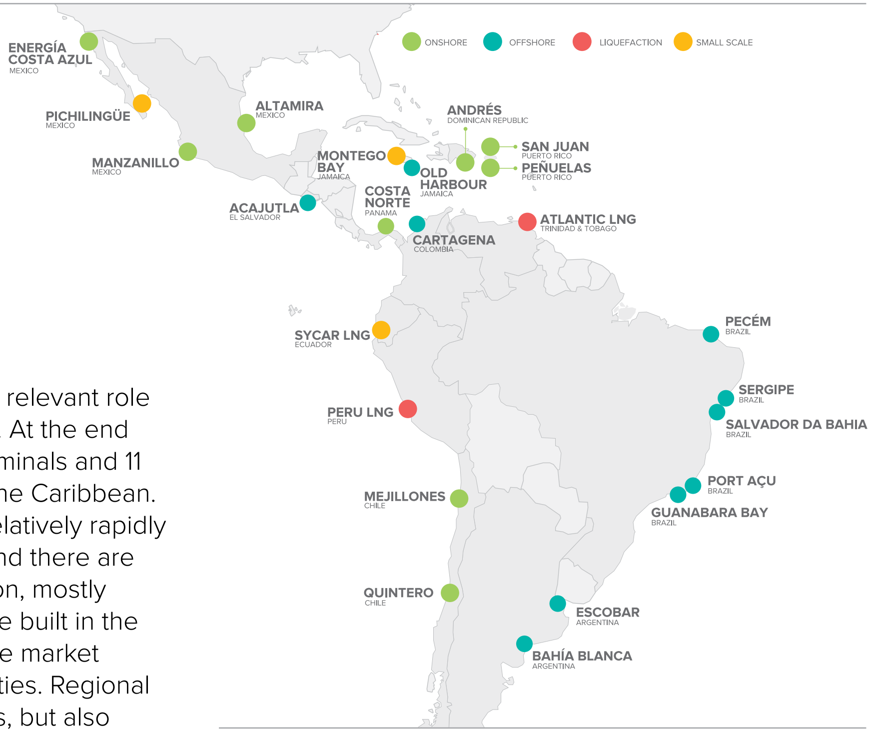
At the same time, abundant oil and gas discoveries have been made offshore Guyana and Suriname, complementing other integration opportunities in the sub-region.

Mexico-USA

The shale revolution in the USA was a game-changer for energy relations with Mexico. After building interconnection pipeline infrastructure, Mexico gained access to the massive and very competitive shale resources in the USA. Today, more than 70% of natural gas supply in Mexico is imported via pipelines from the USA, relegating LNG terminals to a secondary role. However, this situation created the opportunity to export American gas through Mexico, via LNG, reversing existing terminals. One of them in Baja California is now in the retrofitting process to become a liquefaction facility, taking advantage of its strategic location in the Pacific basin. Other projects are now being examined (see the Mexico chapter).

LNG as a new means for integration

LNG is called upon to play an increasingly relevant role in the global gas market and in the region. At the end of 2022, there were 22 LNG receiving terminals and 11 importing countries in Latin America and the Caribbean. LNG infrastructure has been developed relatively rapidly in the region, mainly in the last 15 years, and there are prospects for ongoing terminal construction, mostly flexible FSRUs. The more terminals that are built in the region and in the world, the more liquid the market becomes, opening up business opportunities. Regional integration is not only a matter of pipelines, but also of LNG, which provides great flexibility and mitigates investment risks.



LNG Terminals in LAC

Source: ARPEL

ONSHORE · OFFSHORE · LIQUEFACTION · SMALL SCALE

ESG performance

ESG performance indicators are here to stay

ESG (Environmental, Social & Governance) key indicators are not a new concept. Multilateral financial institutions have used metrics or standards to assess the performance of potential investments for several decades, but it was not until 2004 that the term was used formally by the UN Global Compact in the Report "Who cares wins[1]", aimed at improving integration of ESG issues in asset management. The initiative was endorsed by 23 financial institutions led by the International Finance Corporation (IFC)[2], and since then, more and more projects and firms have been using ESG key indicators to measure their performance and convey the results publicly in a consistent format.

Nonetheless, the use of ESG indicators to manage investments has not been without controversy. Some investors argue that fund managers are not complying with their fiduciary duties by basing investment decisions on ESG indicators that do not necessarily represent the best potential financial returns. At the same time, there are stakeholders demanding more clarity and transparency in ESG reporting because they believe that these indicators are being used to "greenwash" investments.

The controversy is not over and will remain for a while. ESG indicators are in their infancy, and some compare them with accounting rules that, in the beginning, did not have standard regulations causing different financial results. However, those accounting rules have been modified over a century to make them more transparent and universal.

It is worth mentioning that a lack of data or poor-quality information on ESG performance can negatively affect the perception of any industry, not only those in the energy sector. A company's ability to assess and manage the impacts of climate change, for example, has become a normalized part of investor and rating agency strategic business risk analysis.

Embracing sustainability reporting, with an emphasis on metrics and targets, opens an opportunity for gas companies to reinforce the trust that society claims. Its implementation can provide many benefits, among them, improvement in access to capital and enhancing credibility with customers.

In addition to climate change issues, there is a wide range of ESG factors for companies in the gas industry to manage and report on, including social factors such as community engagement and employee safety, as well as governance issues such as transparency and ethical business practices. By considering and addressing all of these ESG factors, gas companies can attract investment, improve their reputation, attract talent, and contribute to a more sustainable future.

[1] "Who cares wins, 2004-2008" IFC Advisory Services in Environmental and Social Sustainability. Publications of the initiative: (2004 – Connecting Financial Markets to a Changing World). (2005 – Investing for Long-Term Value) (2006 – Communicating ESG Value Drivers and the Company-Investor Interface) (2007 – New Frontiers in Emerging Markets Investment) (2008 – Future Proof? Embedding ESG issues in Investment Markets).
[2] International Finance Corporation, World Bank Group.

Towards a reporting framework

Clearly, the oil and gas industry is key to the rapid reduction of GHG emissions, which can be achieved, inter alia, by implementing more efficient production methods, reduction of flaring and methane emissions, by capturing and storing carbon emissions, and by investing in renewable energy sources. Reductions in GHG emissions, however, need to be measured, and companies need a framework against which to measure and report their progress. Investors and consumers need this too.

Voluntary environmental disclosure is now familiar to many businesses, and several reporting frameworks have been developed, allowing stakeholders to gain anything from a general understanding of a company's ESG performance to insights on specific benchmarks for each sector. Then, with the Paris Agreement in 2015[3], the ESG agenda received a determining stimulus, and reporting expectations reflecting governments' commitments on GHG emissions began to emerge.

Formed in April 2015 by the Financial Stability Board at the request of G20 Finance Ministers and Central Bank Governors, the Task Force on Climate-Related Financial Disclosures (TCFD), seeks to strengthen and protect global financial markets from systemic risks such as climate change. Its recommendations lead the public and private sectors to disclose information related to the financial implications of climate change risks and how this is integrated into business decision-making. The TCFD covers disclosures from the financial sector (banks, insurance companies, asset managers, asset owners) to non-financial groups (energy, transportation, materials, buildings, agriculture, food, and forest products).

The TCFD's 2022 Status Report[4] highlights that "Through widespread adoption, financial risks and opportunities related to climate change will become a natural part of companies' risk management and strategic planning processes. As this occurs, companies' and investors' understanding of the potential financial implications associated with climate change will grow, information will become more decision-useful, and risks and opportunities will be more accurately priced, allowing for the more efficient allocation of capital."

TCFD Recommmendations and Supporting Remmended Disclosures

Source: Disclosure 2022 Status Report[5]

GOVERNANCE	STRATEGY	RISK MANAGEMENT	METRICS AND TARGETS
Disclose the company´s governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the company´s businesses, strategy, and financial planning where such infirmation is material.	Disclose how the company indentifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.

[3] To tackle climate change and its negative impacts, world leaders at the UN Climate Change Conference (COP21) in Paris reached a breakthrough on 12 December 2015: the historic Paris Agreement. The Agreement is a legally binding international treaty. It entered into force on 4 November 2016. Today, 194 Parties (193 States plus the European Union) have joined the Paris Agreement.
[4] TCFD, 2022 Status Report, October 2022.
[5] TCFD, 2022 Status Report, October 2022.

Another international collaboration, setting out best practices, recommendations, and instructions on how to report key ESG data, is the "Sustainability reporting guidance for the oil and gas industry" published by **Ipieca, API and IOGP**[6] , providing a robust framework that guides companies on how to structure their reporting and establishes sustainability metrics for the sector selected through industry consensus.

In particular, on GHG emissions, the report involves performance data ("dating back long enough to allow trend analysis") including methane emissions, energy use, and flared gas. These disclosures include Scope 1, Scope 2 and, as appropriate, Scope 3 GHG emissions, which refer to those emissions generated indirectly across the entire value chain[7]. Notably, in relation to mitigation, the approach includes those planned activities and estimated costs from projects on combustion, energy efficiency, flaring, venting, and fugitive leaks, as well as additional initiatives like CCS, carbon offsets, and nature-based solutions, such as reforestation and enhanced forest management. The unique goal of this is to maximize all alternatives to mitigate the adverse effects of climate change.

On the other hand, the **Sustainability Accounting Standards Board (SASB)**, in its framework for Oil & Gas Exploration and Production[8], includes both quantitative and qualitative (discussion and analytics) measures, from GHG emissions, air quality, water management, biodiversity impacts, security, human rights, workforce health and safety, reserves valuation and capital expenditures, business ethics and transparency to critical incident management. The SASB's use of the term "sustainability" refers to corporate activities that maintain or enhance the ability of the company to create value over the long term.

In addition, with the goal of aligning investors with the broader objectives of society, the UN "**PRI-Principles for Responsible Investment"** framework helps investors to "understand the investment implications of ESG factors, and to support its international network of investor signatories in incorporating these factors into their investment and ownership decisions". It seeks to incorporate voluntary disclosures by participating members (signatories) under six core principles committing them to incorporate ESG issues in investment analysis and decision-making processes[9].

In many sectors today, the implementation of metrics over a prescribed timeframe is critical to achieving long-term business sustainability, and companies have many frameworks to guide them, whether sectoral or independent (Domini 400, FTSE4Good or Dow Jones). ESG performance measurement and reporting is here to stay and will evolve, with more countries likely to develop regulatory frameworks to improve transparency and standardization across the board.

According to S&P Global, in 2021, *"we saw larger asset owners, asset managers, and banks adopt negative screening strategies — in other words, exclusion or divestment of companies with weak ESG practices or high exposure to ESG risk"*[10]. All of this means increasing pressure on oil and gas managers and boards to keep their firms profitable and simultaneously comply with more challenging ESG indicators.

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[6] "Sustainability reporting guidance for the oil and gas industry", IPIECA, API, IOGP, Fourth Edition published in March 2020, updates in February 2023. ARPEL endorsed this document.
[7] Module 3, Climate and Energy Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.
[8] SASB, "Oil & Gas Exploration and Production", October 2020. As of August 2022, the International Sustainability Standards Board (ISSB) of the IFRS Foundation assumed responsibility for the SASB Standards. The ISSB has committed to build on the industry-based SASB Standards and leverage SASB's industry-based approach to standards development. The ISSB encourages preparers and investors to continue to provide full support for and to use the SASB Standards until IFRS Sustainability Disclosure Standards replace SASB Standards.
[9] PRI-"Principles for Responsible Investment":
- ***Principle 1:*** *We will incorporate ESG issues into investment analysis and decision-making processes.*
- ***Principle 2:*** *We will be active owners and incorporate ESG issues into our ownership policies and practices.*
- ***Principle 3:*** *We will seek appropriate disclosure on ESG issues by the entities in which we invest.*
- ***Principle 4:*** *We will promote acceptance and implementation of the Principles within the investment industry.*
- ***Principle 5:*** *We will work together to enhance our effectiveness in implementing the Principles.*
- ***Principle 6:*** *We will each report on our activities and progress towards implementing the Principles*

[10] S&P Global: "Key trends that will drive the ESG agenda in 2022", January 2022.

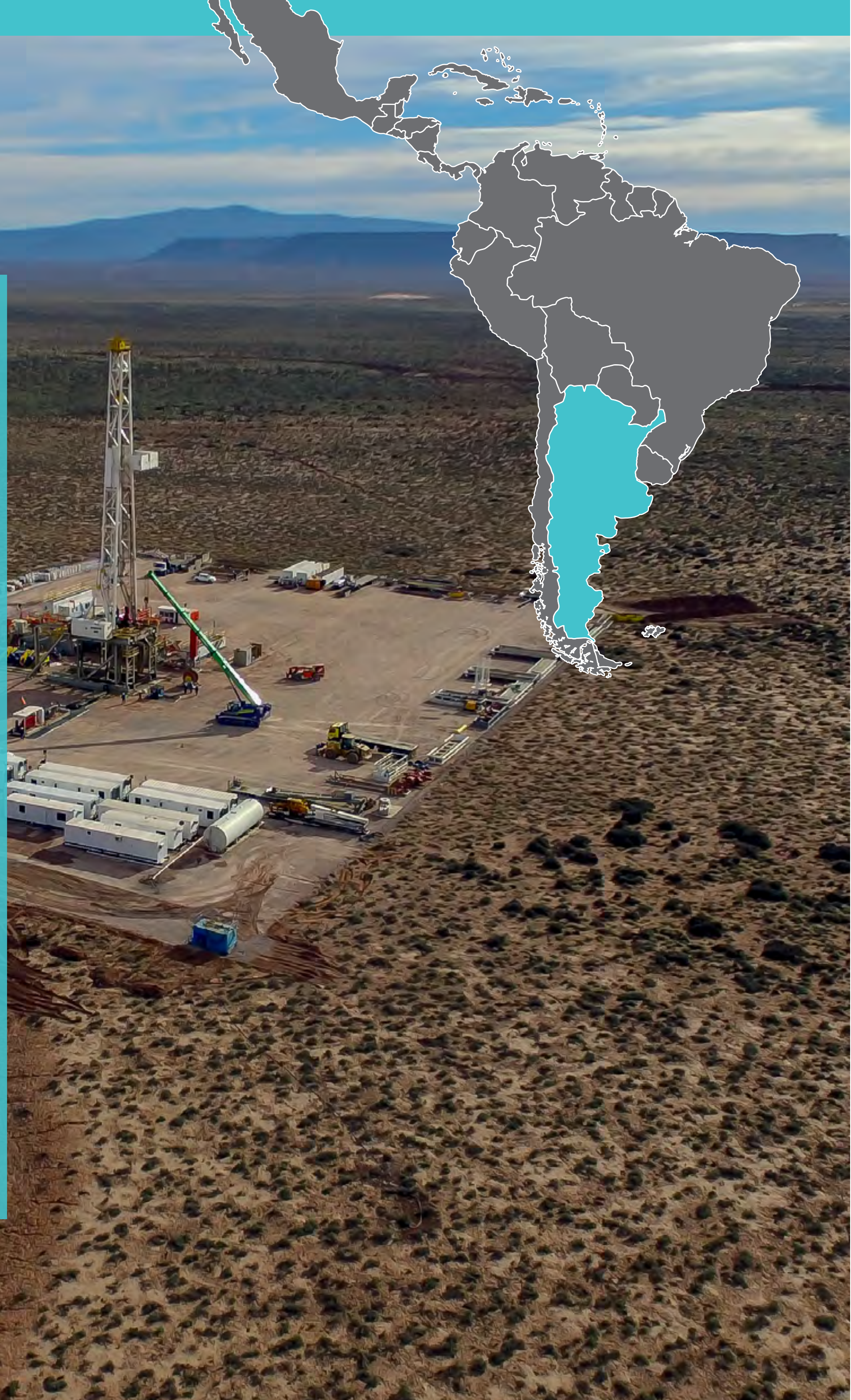
SECTION 5

Countries' Insights

COUNTRIES' INSIGHTS

Argentina

Vaca Muerta, a world-class shale gas play to decarbonize the region and other parts of the world



Natural Gas in the Energy Matrix

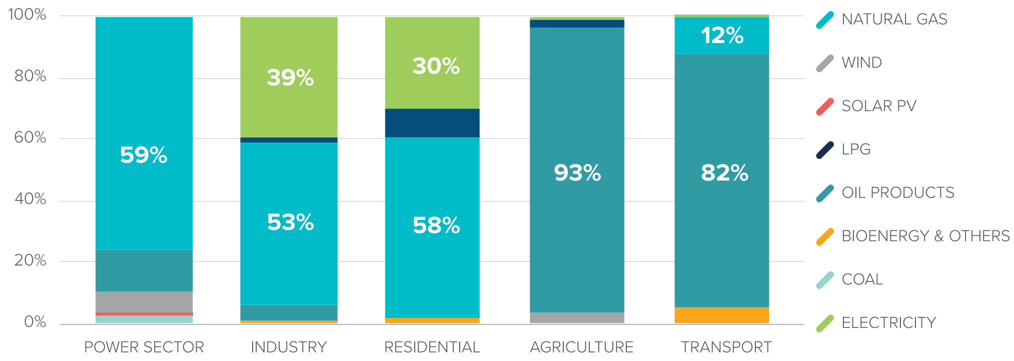
Natural gas represents around 56 % of Argentina's total primary energy supply, being one of the countries with the largest share of natural gas in their energy mix globally.

Natural gas demand averaged 117 Mm3/d in 2021. The country has an extensive transport and distribution system, covering all the large cities and reaching 8.6 million households around 60% of total, the highest share in Latin America. Natural gas is mainly used for heating in winter, water heating, and cooking. Both public and private entities participate in the commercialization and transportation of natural gas. From a demand-side perspective, natural gas is also a key energy source in all sectors, which represented 54% of the energy supply for power generation, 53% for the industrial sector, 58% for the residential sector, and 12% for the transport sector in 2021.

The gross natural gas production averaged 124 Mm3/d in 2021. However, as residential use for heating is very high, natural gas demand has an important seasonality. Consumption in winter is typically around 150 Mm3/d, while in summer is a little less than 100 Mm3/d (IAPG). As there are no large storage facilities — unlike Europe — Argentina needs to cover part of its demand, mainly in winter, with imports via pipeline from Bolivia and LNG from the international market. According to the Enargas Open Data web portal[1], Argentina imports 12 Mm3/d from Bolivia and 10 Mm3/d via LNG through the Escobar and Bahía Blanca terminals, on average. Argentina also exports natural gas to Chile — mainly in summer, taking advantage of spare capacity —, Uruguay and Brazil. On average, exports were 2.6 Mm3/d in 2021, 85% of this volume was sent to Chile.

Energy Consumption by Demand Sectors

Data Source: Argentina's Energy Secretariat



Total Energy Supply (ktep)

Source: Argentina's Energy Secretariat

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Var. % 2021-2020	% 2021
Coal	1235	1,125	1,375	1.358	1.048	1,077	1,179	699	861	1,208	40.31%	1.48%
Electricity	655	693	848	771	819	900	822	919	405	215	-46.98%	0.26%
Natural Gas	45,220	45,067	45,739	46.486	47.180	47,318	47,972	47,536	44,445	45,317	1.96%	55.58%
Hydropower	3,194	3,583	3,562	3.530	3.250	3,459	3,500	3,001	2,608	2,170	-16.79%	2.66%
Nuclear	1,854	1,850	1,280	2.204	2.224	1,745	1,850	2,200	2,778	2,823	1.59%	3.46%
Oil and Oil Products	25,466	26,665	25,768	26.579	26.208	24,668	22,772	22,237	19,492	24,796	27.21%	30.41%
Others	3,123	3,163	3,525	3.664	3.561	4,189	4,157	4,645	4,349	5,009	15.16%	6.14%
Total	80,748	82,146	82,096	84.591	84.290	83,355	82,253	81,236	74,939	81,537	8.80%	100%

[1] https://www.enargas.gob.ar/secciones/datos-abiertos/datos-abiertos.php.

The Impact of Vaca Muerta's Unconventional Gas Resources

Argentina has one of the world's most proliferous non-conventional natural gas plays, the Vaca Muerta formation (shale gas). According to EIA, the estimated technically recoverable non-conventional gas resources of Vaca Muerta are 308 Tcf.

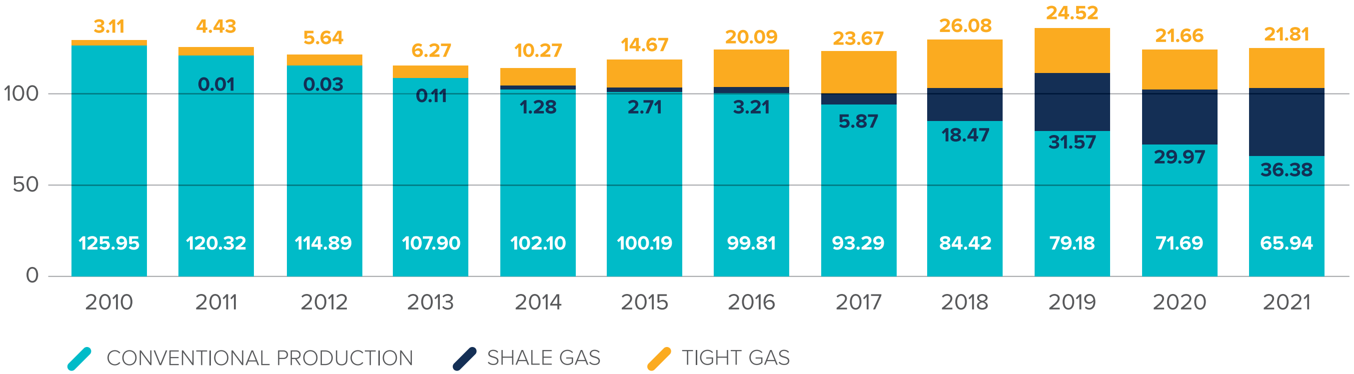
Since Vaca Muerta started to be exploited, the natural gas supply has changed dramatically, moving from the declining conventional production trend in the decade of 2010s to become 47% of the total supply nowadays. The development of unconventional oil and gas in Argentina has attracted around US$26.8 billion in investment, most of it to Vaca Muerta (Energy Secretariat)[2], helping to improve the country's weak macroeconomic environment. Vaca Muerta has demonstrated the quality of its world-class resources, and the capacity of the Argentine industry to develop them.

However, as resources and production are now more geographically concentrated, mainly in the Neuquén Province, new challenges arise to scale up production and take advantage of current opportunities. The first is the need for transportation infrastructure, which is becoming a bottleneck for the country. To that end, Argentina is building the Néstor Kirchner gas pipeline to increase transport capacity from Vaca Muerta to Buenos Aires and the north of the country. The second challenge is market development, with existing national, regional, and international opportunities. While there are very good opportunities to decarbonize the power, land, or maritime transport sectors in the country, the vast natural gas resources existing in Argentina could reach their full potential if international markets are developed.

Natural Gas Gross Production by Type of Resource

2010 - 2021 / Million m³/d

Source: Enargas



[2] http://datos.energia.gob.ar/dataset/inversiones-en-mercado-de-hidrocarburos-upstream.

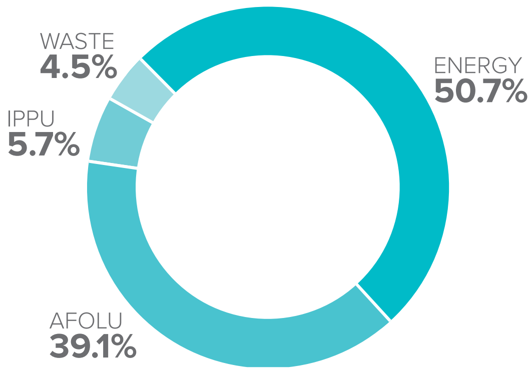
In that sense, Argentina is very well connected to its neighbors (Chile, Uruguay, Bolivia, and Brazil) via several pipelines. Deepening regional energy integration is critical to leverage Vaca Muerta resources, balance supply and demand, and take advantage of complementarities while increasing energy security and business opportunities. Perhaps the most challenging step, initial interconnection infrastructure, has already been built and has considerable spare capacity.

In the mid term, Argentina would have the possibility to export LNG to international markets, helping to decarbonize other regions via coal substitution in power generation and industry. Significant investments are needed; developing a 24 Mm3/d LNG liquefaction terminal is estimated to take from four to six years and cost around US5 billion.

GHG Emissions by Sector
2018

Source: GHG Inventory https://inventariogei.ambiente.gob.ar/resultados

Total GHG Emissions: **365.89 $MtCO_2e$**



Scaling up Vaca Muerta would also bring opportunities for economic development in Argentina. According to IAPG, Argentina's Oil and Gas Institute, the oil and gas industry represents 2.6% of GDP; it directly employs more than 75,000 people, and indirectly more than 375,000.

Recently an investment of US$540 million by CAF was announced for enhancing natural gas infrastructure. The plan involves the construction of the La Carlota-Tío Pujio gas pipeline, the reversal of Norte gas pipeline and the compressor stations. This work will increase the supply of gas to the north of the country from Vaca Muerta and also increase the possibilities of gas export volumes to Chile and Brazil.[3]

It is a fact that the daily production volume of Vaca Muerta increases day by day and Neuquén breaks gas extraction records more and more often. On the other hand, it is still necessary to have the adequate infrastructure and finalize trade agreements that guarantee exports. There are already negotiations with Brazil for the extension of the gas pipeline that will allow gas to be exported from Vaca Muerta to the neighboring country.

In sum, Argentina has the natural gas resources to help decarbonize the region and other parts of the world, mainly by substituting coal, while fostering a key value chain with a critical role in the country's economic output. Natural gas provides the flexibility needed to continue developing high-quality wind and solar resources, aligned to other decarbonization efforts. However, the impact of Argentina's natural gas in global decarbonization by replacing coal in Asia and other regions could be far more effective than that of Argentina's own decarbonization, which accounts only for 0.5% of global annual GHG emissions[4].

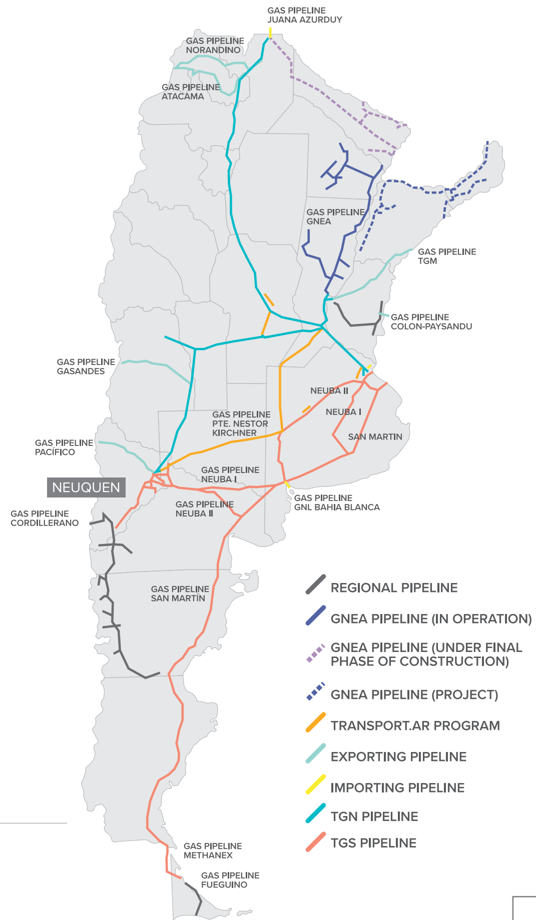
Oil & Gas Industry

2.6% GDP

+ **75,000** direct jobs
+ **375,000** indirect jobs

Argentina Natural Gas Transport Pipelines

Source: https://gpnk.energia-argentina.com.ar/



[3] https://www.argentina.gob.ar/noticias/massa-acordo-con-la-caf-un-credito-por-usd-540-millones-para-aumentar-envios-de-gas-desde.
[4] BP Statistical Review of World Energy 2021

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COUNTRIES’ INSIGHTS

Bolivia

Natural gas as the key for economic development

Socio-economic situation

Bolivia's intrinsic characteristics are essential for understanding its socio-economic development, sustainably related to its policy decision-making. Its population density is one of the lowest in the world with 11 people per km2. The average age[1] is 25.6 years: a result of the high fertility rate in the past decades (5.7 live births per woman in 1980 and 2.8 in 2020, the current figures being above the world average, which is 2.3). There has been an improvement in life expectancy from 50 years in the 1980s to 65 today. Additionally, the topography of the country hinders its economic growth and poses continuous challenges to its competitiveness.

As of today, Bolivia's GDP per capita is one of the lowest in Latin America and the Caribbean, below US$5,000. In the last decade, the country has experienced a profound economic shift, driven by the commodity boom of hydrocarbons and minerals. FOB[2] exports of hydrocarbons represent 33% of the country's income, only beaten by the mining sector, according to Bolivia's Central Bank.

Additionally, as highlighted by the World Bank, Bolivia's economic model is based on state-led public investment, but with the facilitation of private investment in important areas, with high public spending to maintain economic growth.

Natural gas and minerals exports have driven the country's economy to more than double in the last two decades, though GDP per capita is still far below the regional average.

GDP/per capita

$5,000

GDP Growth

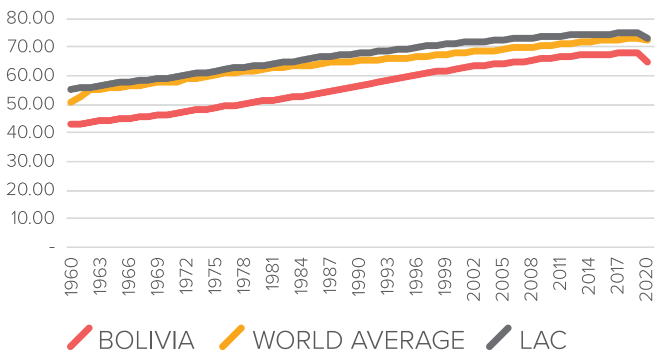
(2001-2021)

+210%

constant 2015 USD

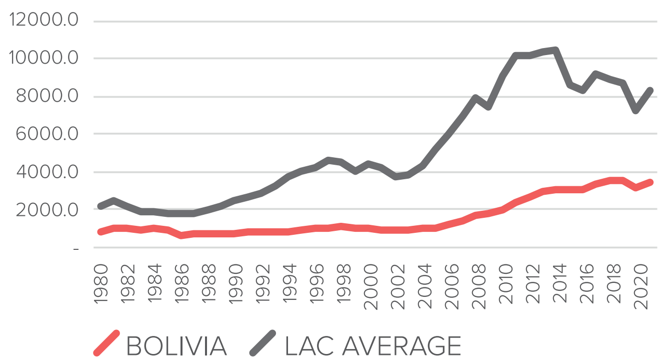
Life expectancy at birth (years)

Data Source: World Bank (WDI Database)



GDP/per capita (US$)

Data Source: World Bank (WDI Database)[3]



[1] Average age: is the age that divides a population into two numerically equally sized groups; that is, half the people are younger than this age and half are older.
[2] FOB: Free on Board.
[3] https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.

Natural gas resources

Bolivia is one of the largest gas producers in the Southern Cone, with export capacity to Brazil and Argentina playing a fundamental role for the economy[4] and providing huge flexibility to accommodate its neighbors' gas demand.

Bolivia enjoys a potential 12 Tcf[5], reservoir in the Madre de Dios basin, which would support a prolonged gas export status for the country. Policymakers are currently evaluating options to provide clearer support to attract overseas capital. Among these, new fiscal regimes could be crucial to attract more E&P investments. Since the publication in 2021 of an upstream reactivation plan[6], the government has approved new exploration projects, and in 2021, the National Oil Company, YPFB, launched a five-year plan that focuses on exploration and evaluation activities to increase production and reserves. It comprises 27 exploratory opportunities in the sub-Andean and foothills of Bolivia with estimated recoverable resources of 18 Tcf of natural gas and 320 million barrels of oil and condensate. The investments — both national and foreign — to execute these projects are calculated at US$1.4 billion[7].

To date, the largest market for Bolivian gas is Brazil; a good example of market integration. The sophistication of the Brazilian gas market will provide more opportunities for Bolivian gas, monetizing the intrinsic and extrinsic value of the flexibility. In July 2022, Ambar Energia in Brazil announced four new gas power plants in Cuiabá, expected to be supplied with Bolivian gas through the Bolivia-Mato Grosso gas pipeline. The delivery point is under negotiation.

In Argentina, requirements for Bolivian gas supplies for the upcoming winter periods could decrease as a consequence of the development of unconventional gas assets in Vaca Muerta. However, with new LNG export facilities in Argentina, together with the reversal of the Norte gas pipeline, the completion of the Uruguaiana-Porto Alegre gas pipeline and the integration of markets, there could be better monetization of gas resources internationally leveraging high demand for gas in the Northern Hemisphere during the winter.

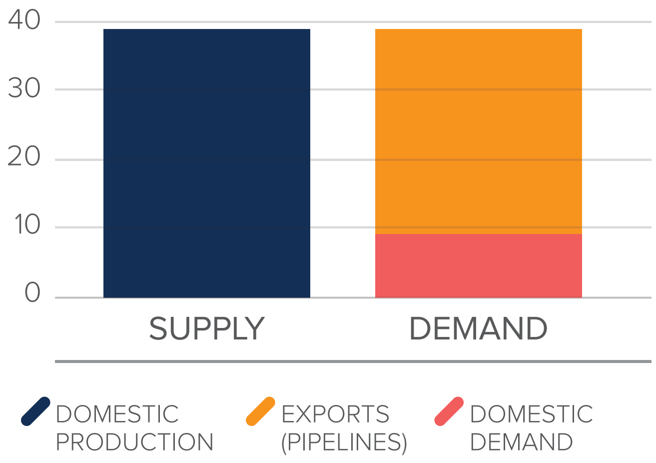
Exploration investments calculated

1.4 US$bn

with national and foreign investment.

Bolivia Gas Balance

Source: ARPEL



[4] https://es.investing.com/news/economy/bolivia-ingresa-3400-millones-de-dolares-por-exportaciones-de-gas-en-2022-2347772.
[5] YPFB, based on Francia Beicip Franlab consultant analysis. (Feb.2023) https://www.ypfb.gob.bo/es/component/content/article/16-tendencias/154-ypfb-estima-que-potencial-hidrocarburifero-de-madre-de-dios-equivale-a-usd-475-mil-millones-2?Itemid=101.
[6] "Plan de Reactivacion del Upstream", https://diputados.gob.bo/proyectos-de-ley-aprobados/.
[7] PEC YPFB 2021-2025.

Fertilizers

As stated by IICA (Inter-American Institute for Agricultural Cooperation), global demand for fertilizers has led to increased prices, already seen before the Russia-Ukraine conflict. This together with the contraction of economies in Latin America and the Caribbean (a drop of 4% against the US dollar in the first half of 2022), resulted in a 137% increase in the price of the region's fertilizer imports.

In the same period, Bolivia's fertilizer imports fell by 38.4% (more than any other country in the region) reducing its dependency on fertilizers from Russia and Belarus from 16.74% to 7.69% of total imports.

Given that Latin America and the Caribbean is a net importer of fertilizers, and a vast majority of countries depend 100% on imports, it is to be anticipated that the drop in import volumes and the rise in prices will have significant effects on yields, production costs, and the agricultural profitability of the region.

For a country like Bolivia, where agriculture represents a much larger percentage of GDP than the world average (13% vs 4.3%, respectively), independence from fertilizer imports is a key priority for economic growth. There are also opportunities for countries like Bolivia to monetize their natural gas resources through demand for fertilizers created by growth in global populations. In 2022, Bolivia announced[8] its plans to build a second fertilizer plant with the goal of transforming Bolivia into a net fertilizer exporter to the region.

137% ↑ **price of the region's fertilizer imports.**

Agriculture percentage of GDP

Bolivia	World average
13%	**4,3%,**

What is more, the Paraná-Paraguay waterway[9] connects the ports of Argentina, Brazil, Bolivia, Paraguay, and Uruguay, and is currently the natural transport corridor for merchandise in the Southern Cone. The transport of fertilizers via the waterway represents 15% of its traffic. If Bolivia becomes a significant exporter of fertilizers in the Southern Cone, this could lead to an increase in the waterway's traffic.

Additionally, there could be exports of fertilizers to the Pacific basin to supply potential Asian demand.

[9] https://www.ypfb.gob.bo/es/component/content/article/15-prensa/145-ypfb-apunta-a-duplicar-la-produccion-de-urea-con-una-segunda-planta-que-consumira-1-tcf-en-20-anos.
[10] "Comision Permanente de Transporte de la Cuenca de la Plata".

Electricity Sector

Bolivia's power mix portfolio is based mainly on hydro capacity (734.8 MW), with CCGT plantes (1,516 MW) and gas peaking (702 MW). Its current objective is for 75% of generation to come from renewables by 2025, with new gas-fired power plants as back-up, as set out in its *"Plan de Desarrollo Económico y Social (PDES) 2021-2025"* and the NDCs 2021-2030[10]. The goal is to give electricity access to all citizens in urban areas and to 95% of citizens in the countryside.

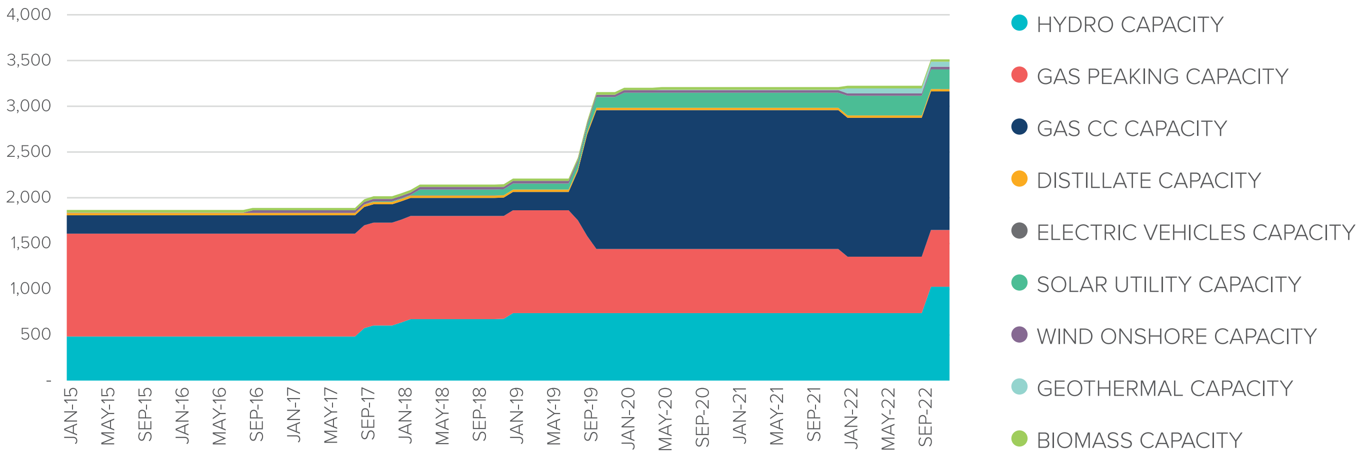
With the addition of new CCGT power plants in 2019 (1 GW), Bolivia has achieved better energy efficiency compared to the former gas peaking plants.

Currently, the system's reserve margin provides good levels of reliability through its thermal capacity, allowing the penetration of new renewable (hydro, solar, and wind) capacity in the coming years.

Some projects are under construction, for example the hydro projects of Miguillas (204.8 MW) and Ivirizu (290.2 MW), which will help to meet an expected increase in power demand.

Bolivia Power Generation Capacity
(MW)

Source: OLADE[11]



[10] "Contribución Nacionalmente Determinada (CND) del Estado Plurinacional de Bolivia, NDC update, period 2021-2030, Paris Agreement.
[11] SIELAC-OLADE.

COUNTRIES' INSIGHTS

Brazil

Economic growth and energy needs

Introduction

Brazil is the largest country in Latin America, accounting for 32% of the regional population, 32% of the region's GDP, and 36% of total energy consumption[1]. Energy demand intensity is slightly lower than the regional average and much lower than that of advanced economies[2].

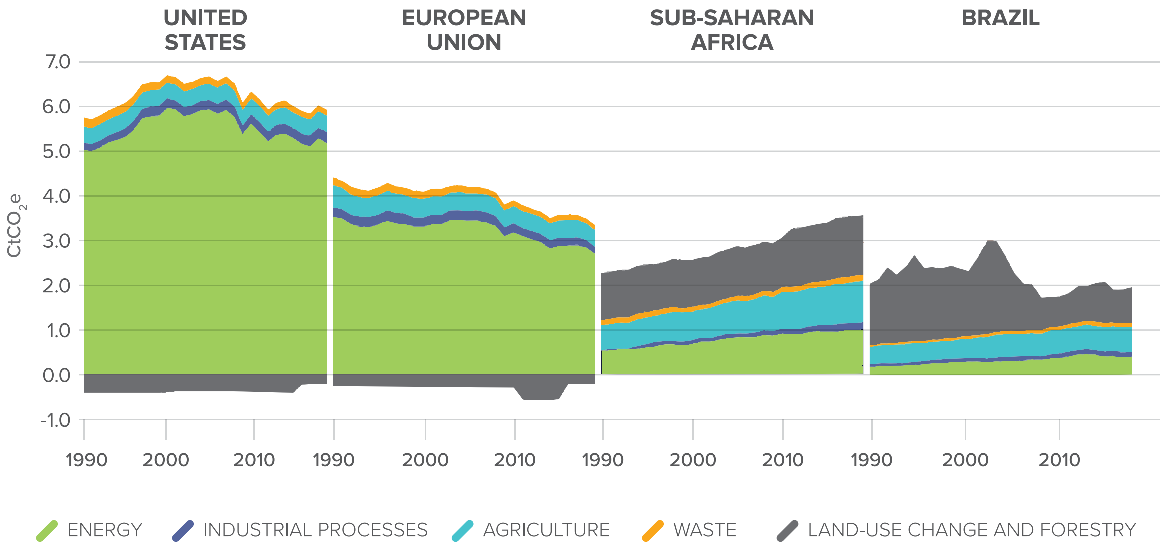
Brazil experienced very limited energy consumption growth in the past decade. It is estimated that, in next decade, a modest economic growth (2%-3% p.a.) will generate an average annual growth of total energy consumption of around 2.5%.

GHG emissions in Brazil

The energy sector in Brazil is not the primary source of GHG emissions. In fact, almost half of the national GHG emissions are released from forestry and land use (FOLU). Agriculture comes second in emissions, while energy (including transport) is third. According to SEEG (GWP-AR5), in 2021, Brazil released a total of 2.4 Gt of CO_2e, where FOLU represented 49%, agriculture 25%, energy (including transport) 18%, industrial processes 4%, and residues 4%[3].

Annual GHG Emissions by region and source
1990-2019

Source: IBP with data from Financial Times and SEEG. https://www.ibp.org.br/observatorio-do-setor/snapshots/emissoes-anuais-de-gases-do-efeito-estufa-por-setor/



(*) Includes emissions from heating in buildings, manufacturing, transport, and construction.

[1] CEPALSTAT. https://statistics.cepal.org/portal/cepalstat/index.html.
[2] IEA Energy Efficiency 2022. https://www.iea.org/reports/energy-efficiency-2022.
[3] Source: SEEG http://seeg.eco.br/en?cama_set_language=en.

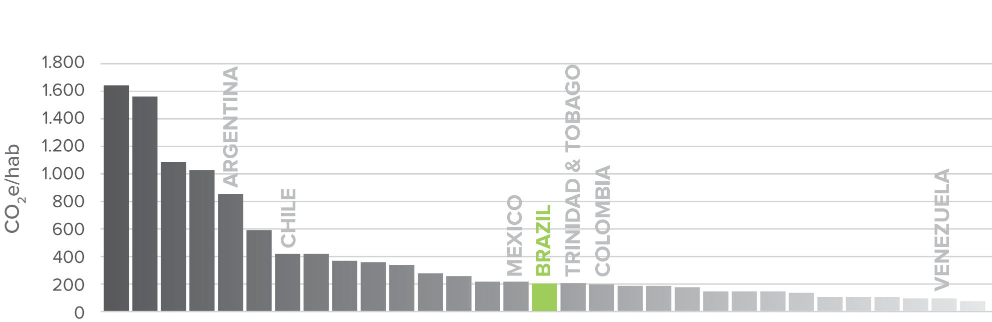
Compared to other countries within and outside the region, carbon-intensive sectors such as transport and power are much cleaner in Brazil due to natural gas and renewable penetration in both sectors.

Brazil reinforced its environmental commitments with the publication of its latest NDCs in March 2022, confirming its pledge to reduce its GHG emissions in 2025 by 37%, compared with 2005[4]. Additionally, at COP26, Brazil's government signed a commitment to end deforestation by 2030, which represents one of the crucial problems that hinder the reduction of GHG emissions today. The main cornerstones to reduce deforestation are fighting illegal activities in the Amazon region, driven by agricultural expansion and illegal wood exploration.

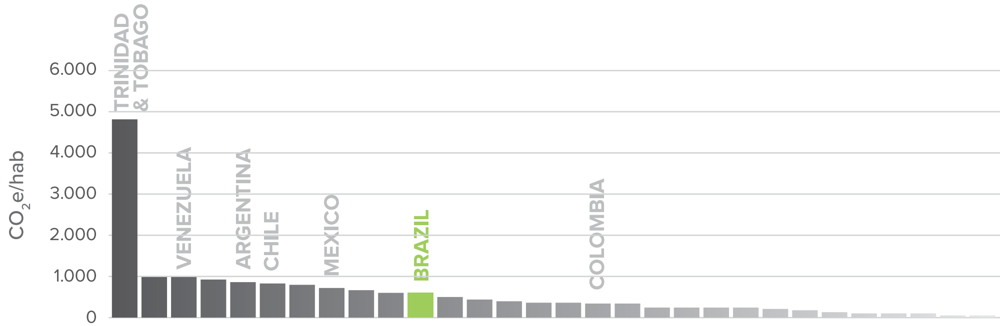
Per capita GHG Emissions by country and sector in Brazil compared to other Latin American and Caribbean countries

Note: 31 Latin American and the Caribbean countries were considered.
Source: EDGAR data

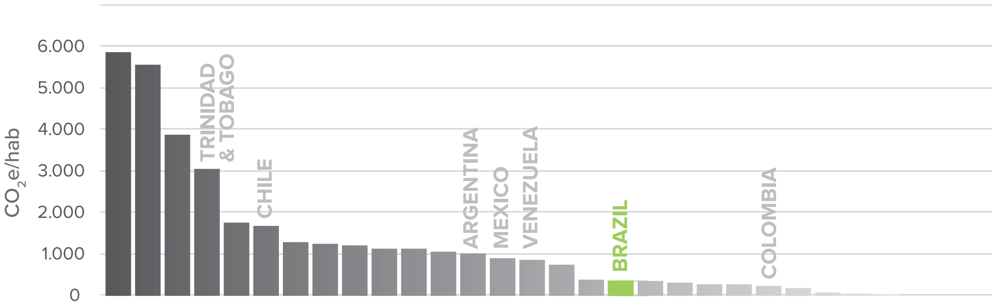
BUILDINGS



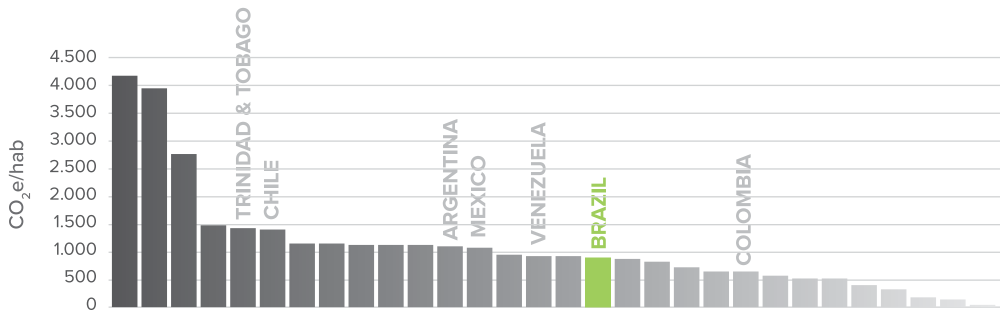
INDUSTRY



POWER SECTOR



TRANSPORT



[4] The quantification of the reference indicator is based on the total net GHG emissions in the reference year of 2005 reported in the "National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not controlled by the Montreal Protocol", Brazilian NDC (2nd Update): https://unfccc.int/sites/default/files/NDC/2022-06/Updated%20-%20First%20NDC%20-%20%20FINAL%20-%20PDF.pdf.

Outstanding biogas and biomethane potential

The increasing amount of waste in modern societies, jointly with the GHG reduction targets, open a clear opportunity for biogas and biomethane production[5]. Brazil has an outstanding potential for biogas production from residues (including agricultural, animal waste, as well as urban residues and wastewater) without the need to use dedicated energy crops. There is also substantial potential from the use of vinasse, which is a by-product of the ethanol and sugar industry.

According to IRENA, the country is the main biogas producer in Latin American and Caribbean both for electricity generation and for off-grid uses.

Generation and Production Off-Grid of Biogas by region in 2020

Source: IRENA Renewable Energy 2022 Report and IRENA Off-grid Renewable Energy Statistics 2022

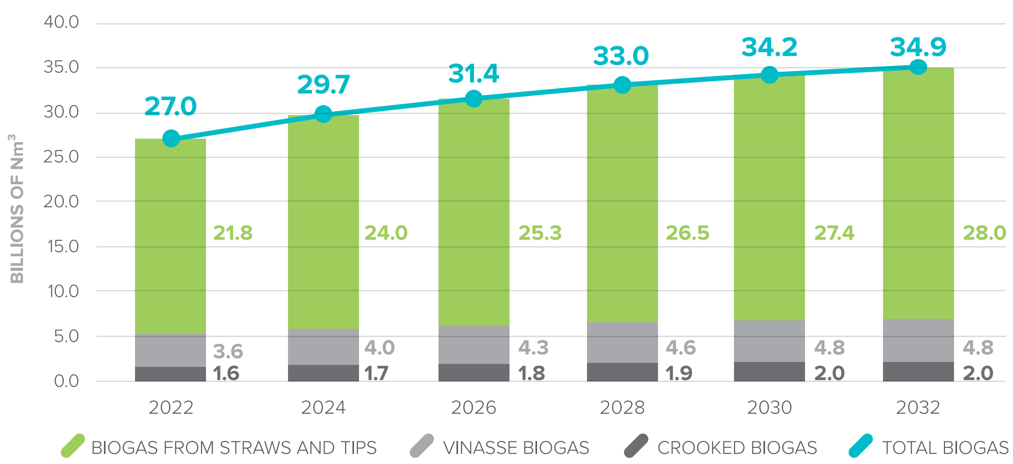
REGIONS	ON-GRID GWH	OFF-GRID 1,000 m^3
Africa	**164**	**60,004**
Asia	**9,359**	**15,194,130**
Oceania	**1,672**	**38**
Middle East	**277**	**1**
Europe	**67,000**	
Germany	33,495	
UK	9,907	
Italy	8,166	
Eurasia	**3,047**	
North America	**13,421**	
USA	12,218	
Latin America[1]	**1,625**	**231,172**
Brazil	1,009	187,437

The use of biogas for power generation has been the main driver for biogas development in Brazil. According to the National Electric Energy Agency (ANEEL), there are currently 423 biogas-fired power plants with a combined capacity of 341 MW, largely with small power plants (< 1MW) in a distributed generation system. The intrinsic attributes of biogas allow for its use in a decentralized way.

When biogas is refined, it generates biomethane, which is equivalent and interchangeable with natural gas and regulated as such. The expectation is that biomethane production will grow substantially in the coming years. Biogas and biomethane are essential for interiorizing and diversifying supply, while also reducing the carbon footprint of gas consumption growth in Brazil.

Brazilian biogas volumes prospects

Source: EPE's 2032 Decennal Energy Plan[6]



[5] IEA underscores in its report "Outlook for biogas and biomethane, 2020" the role that these gases can play in the transformation of the global energy system, highlighting the possibility to integrate rural communities with industries into the energy sector.
[6] https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-689/topico-640/PDE%202032%20-%20Oferta%20de%20Biocombustiveis_27dez2022_envio.pdf

Renewable variability and energy security

Brazil is a leading country for hydropower generation worldwide (it is the second largest hydropower producer), supplying over 60% its annual power demand through large reservoirs with hydropower plants and smaller conventional run-of-river plants. Future hydropower capacity in Brazil will be limited to smaller projects with lower or no storage capabilities (run-of-the-river type) in order to reduce the social and environmental impact of this energy source. With power demand growing faster than GDP, the hydropower system no longer has a multi-year storage capacity and this will continue to fall.

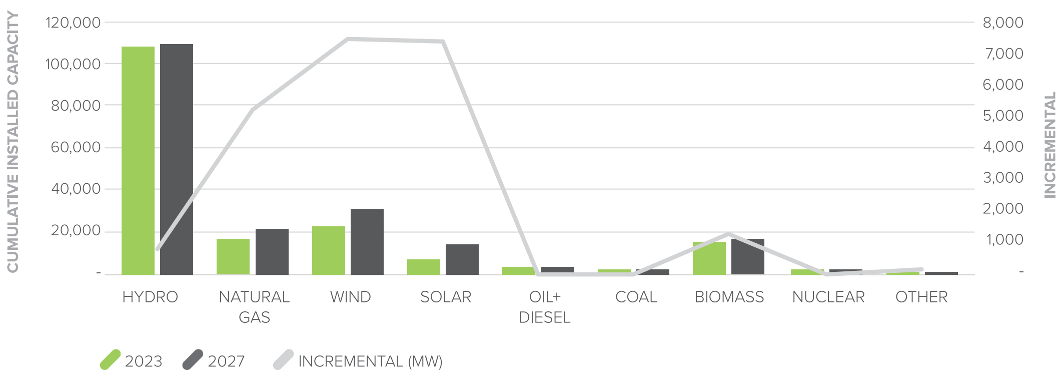
The expansion of the power capacity of the national interconnected system will reach 22.5 GW between 2023 and 2027.. The expansion will be based largely on renewable resources (wind, solar, small hydro, and biomass), equivalent to 76% of new capacity, with the rest being gas-fired power generation (5.2 TWh, or 23% of new capacity), needed to provide security of supply and reliability to the power system for periods of low hydro output and as a back-up to intermittent renewables such as solar and wind. Existing and new gas-fired generation units will reinforce the maturity of the power coverage index and reliability of power supply, thus sustaining economic growth.

In fact, thermal power generation (mostly gas-fired) has historically compensated large seasonal swings in hydro power generation, while other renewables have increased their share in total supply.

With the increase of the share of intermittent renewable power sources, complementary generation requirements switch towards the short term, imposing higher flexibility for thermal units. In this context, local natural gas supply faces challenges in coupling with the power sector, both in providing short-term flexibility (considering that most local gas production is associated with oil) and competitiveness (competing with low-cost renewables).

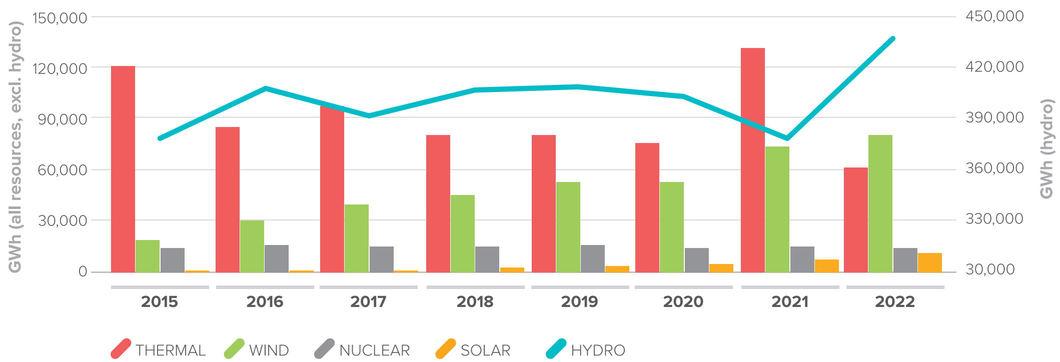
Brazil power installed capacity 2023-2027 (MW)

Source: Operador Nacional do Sistema Elétrico (ONS). Jan-23



Brazil Electricity Generation by source 2015-2022 (GWh)

Source: Based on data from Operador Nacional do Sistema Elétrico (ONS)



Drivers for natural gas growth in Brazil

1. Abundant natural gas reserves

Large natural gas reserves have been discovered with the increase in E&P activities, particularly in the pre-salt area. However, there are still challenges for gas production to reach markets: (i) the predominance of associated gas; (ii) ultra-deep waters and distances from shore; (iii) variable levels of contaminants requiring treatment (such as CO_2); (iv) new infrastructure requirements; (v) domestic market scale to absorb large volumes.
According to EPE (2023)[7], net natural gas production will more than double in the next decade (from approximately 68 mcm/d in 2022 to 134 mcm/d in 2032). The Brazilian government is interested in boosting natural gas use to accommodate such large volumes.

2. Biogas potential

In addition, biogas and biomethane have sizeable potential. ABiogás (the Brazilian Biogas and Biomethane Association) mapped a production potential of over 121 million Mm3/d, which is more than the total national gas production today. This potential has been dubbed the "inland pre-salt". However, such potential faces challenges such as: (i) the lack of capillary infrastructure for gathering supplies and integrating with demand; (ii) the need for aggregation of operations, investments, and logistics, to allow for economies of scale; (iii) need for new and improved local regulatory and fiscal conditions.

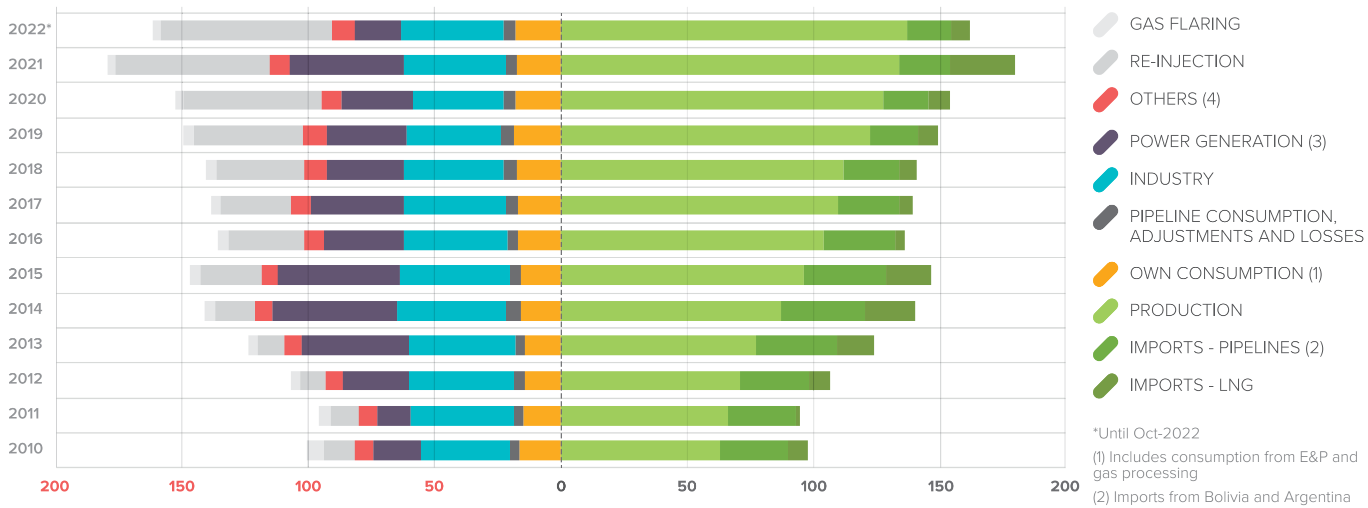
3. Natural gas market reform

The new regulatory framework underpinned by the 2021 Gas Law is aiming at transforming a concentrated and vertically integrated sector into a competitive and diversified market, adopting the principles of unbundling, third-party access, entry-exit transport system, and tariff transparency, and enhancing the flexibility of the gas system. Promoting free competition in the gas market of Latin America and the Caribbean's largest economy will boost the whole region's economic potential.

Initial effects from reforms can be seen through the increasing number of active market players (14 shippers and 12 suppliers[8]) and the increasing number of gas sales contracts to supply local distribution companies and non-regulated consumers (total of 27 as of August 2022). Moreover, after a decade without new gas pipelines, the new authorization regime is now encouraging gas transmission companies to propose new expansions in a much less bureaucratic manner.

Brazilian natural gas supply and demand

Source: Data from MME, ANP, Abegás and Petrobras



*Until Oct-2022
(1) Includes consumption from E&P and gas processing
(2) Imports from Bolivia and Argentina
(3) Includes cogeneration
(4) Includes Comercial, Residential, Automotive and others

[7] 10-Year Energy Expansion Plan 2032.
https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2032.
[8] CMGN, 3Q 2022 Report, https://www.gov.br/mme/pt-br/assuntos/secretarias/petroleo-gas-natural-e-biocombustiveis/novo-mercado-de-gas/cmgn/publicacoes/13RelatrioTrimestralCMGN3T2022.pdf.

4. Important and continuing role of natural gas in the power sector

Gas-fired power generation is critical to ensure the reliability of power supply in Brazil, and it is paving the way for a large increase in intermittent renewable sources. The current market reforms in the power sector foster the development and division of energy and capacity contracting. Gas-fired power plants will play a role in both markets seeking to overcome the aforementioned challenges of competitiveness and flexibility.

The new gas market program in Brazil[9] has, therefore, an inner duty to facilitate integration and management of intermittent renewables into the power system, while expanding overall gas demand and supply competitiveness.

5. Increasing use of natural gas in transport and industry

Transport

CNG is a competitive alternative to liquid fuels, particularly for lightweight vehicles, and it is widely used in urban centers close to gas pipelines (competing with gasoline and ethanol), but it has a limited reach across the country.

Use of LNG in heavy-duty vehicles (replacing more expensive and more polluting diesel) is seen as a great opportunity to increase gas demand and to decarbonize a hard-to-abate sector, but there are still some hurdles to its widespread adoption (from higher vehicle acquisition costs to a lack of fueling infrastructure). Initial discussions on developing LNG “blue corridors” and also increasing the use of LNG in maritime/cabotage or railway transportation are taking place, but they are still seen as niches or medium-to-long-term possibilities.

Industry, metallurgy, and extractives

In industry, natural gas can displace more polluting fuels and promote the expansion of industrial production. There are opportunities to displace coal or coke in the steel and chemical industry and increase the use of natural gas in mining activities, displacing other fuels (e.g., fuel oil, diesel).

Fertilizers

Brazil is an agricultural powerhouse and the world’s top importer of fertilizers, importing 85% of all fertilizers used in its agribusiness. The acceleration of world population growth, with the next 1 billion people expected in 15 years, makes fertilizers a key prerequisite to ensure food security across the globe[10].

According to the Brazilian Central Bank, the value of imported fertilizers in Brazil reached a peak in 2021, reflecting the favorable scenario for the production of agricultural commodities. At the same time, as Russia is the main supplier for NPK fertilizers (nitrogen, phosphorus, and potassium), the conflict with Ukraine raised import dependence concerns.

Natural gas availability in Brazil and its use as feedstock for nitrogen fertilizers[11] offers a great opportunity to Brazil to move towards a reduction of its import dependence in fertilizers and to enhance the worldwide security of supply of agricultural products such as soybeans and sugar. In March 2022, Brazil launched its National Fertilizers Plan, a guideline for developing the domestic fertilizer market, by seeking to increase natural gas competitiveness while reducing fertilizer imports to about 45% by 2050.

It is important to consider that fertilizers, like natural gas, are traded in an international competitive market. The competitiveness of natural gas is thus key to really turning Brazil into a self-sufficient country in nitrogen fertilizers.

[9] IEA, Novo Mercado de Gás The Brazilian Gas Market enters a new era, March 2021.
[10] As raised in November 2022 by WTO and FAO, calling for urgent action to address the fertilizers crisis and outlining policy recommendations for G20 governments.
[11] Gas is the main raw material for the production of nitrogen fertilizers, and gas costs represent 80% of total costs of nitrogen fertilizers.

6. Gas as a transition fuel in Brazil

As an unavoidable process, energy transition will alter the energy mix toward low-carbon energy sources, and gas will be part of this transformation.

As discussed above, due to a lower carbon intensity than other fuels, natural gas and biogas can fuel activities (transport, power, and industry), ensuring energy security and enabling economic development while limiting GHG emissions rise.

They create conditions to underpin penetration of renewables in the power sector (as complementary energy sources, coping with inherent variability from renewable sources) and serve as competitive fuels in the transport sector.

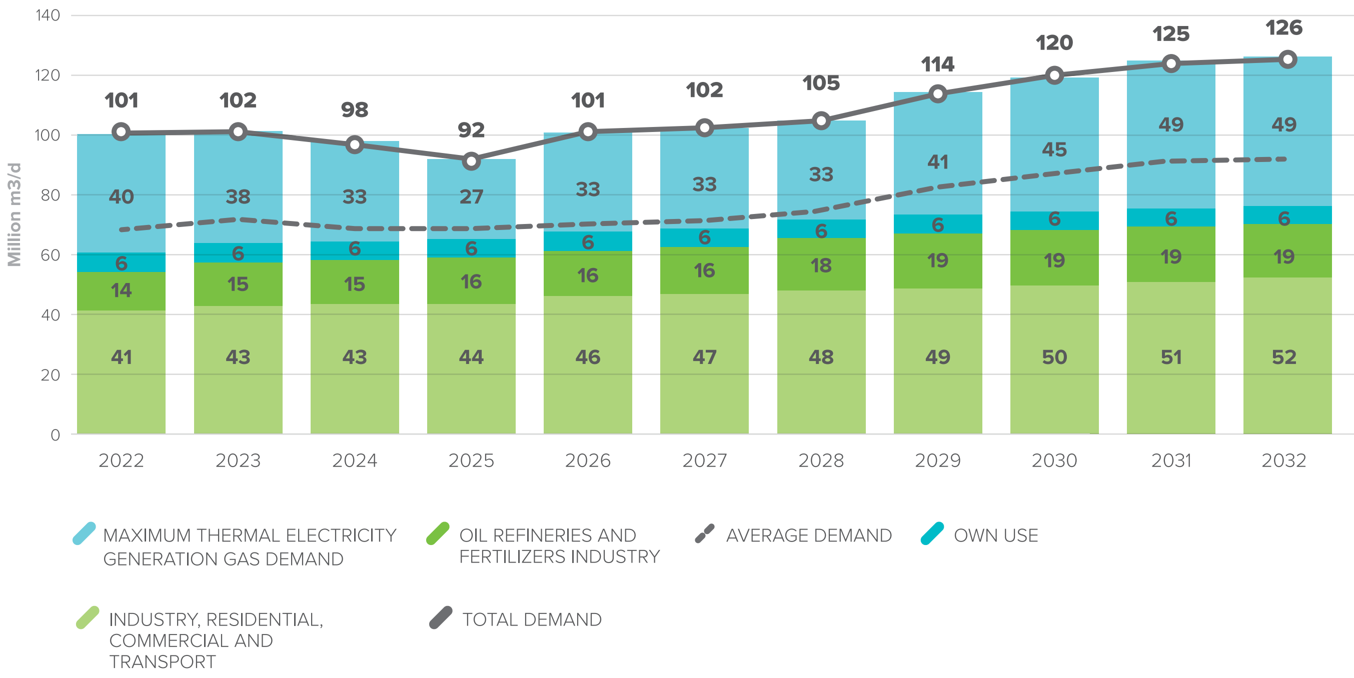
7. Development of the gas transportation network

Since natural gas is a transition fuel in Brazil, its proper transportation is essential for the energy transition in the country. According to EPE (2022)[12], in the Ten-Year Energy Expansion Plan 2031, an additional demand of 39 Mm^3/day is expected, with the total demand from the integrated grid reaching 133 Mm^3/day. Supply is expected to increase including the production of gas from the pre-salt area.

The integrated gas transportation system is an essential driver for the natural gas in Brazil since the system connects the various natural gas supply sources to the demand centers, increasing gas competitiveness in the country.

Projected Natural Gas Demand (integrated gas grid) Reference Scenario

Source: EPE - 10-year Energy Expansion Plan 2023-2032



https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-689/topico-640/Caderno%20de%20Ga%CC%81s%20Natural%20-%20PDE%202032%20-%20rev1.pdf

[12] Ministry of Mining and Energy, Brazil, Empresa de Pesquisa Energética, Plano Decenal de Expansão de Energia 2031 / Ministério de Minas e Energia, Brasília: MME/EPE, 2022. [https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/Documents/PDE%202031_RevisaoPosCP_rvFinal_v2.pdf] Accessed on 6 March 2023.

COUNTRIES’ INSIGHTS

Central America and The Caribbean

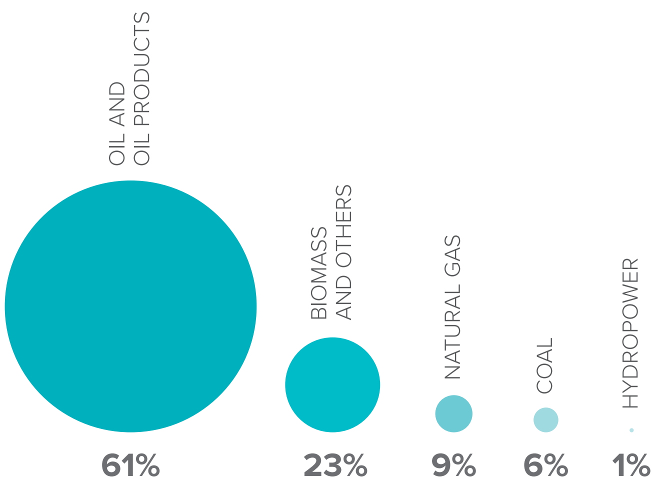
LNG as the key for
phasing out coal and liquids

Countries of Central America and the Caribbean rely primarily on imported fossil fuels for power generation and transport. With only a few exceptions, such as Trinidad & Tobago, which are large oil and gas producers, and Cuba, Belize, or Guatemala, which are small producers but are not self-sufficient, the countries in this sub-region are not oil and gas producers. In the last few years, the trend has been to close down oil refineries because of challenges like the absence of economies of scale in their small markets and the need for significant upgrading investments to produce up-to-date fuels. Consequently, oil products have a significant share of total imports; and the countries of the region are exposed to price volatility. Coal also plays an important role in the power generation mix.

GHG emissions from power generation in the Caribbean account for almost 6 tCO_2/tep, by far the highest in the region. Central America is closer to the average, around 2.5 and 3.0 tCO_2/tep (see chart). In the case of Central America, conventional renewable energies have been partially developed, with a significant share of hydropower or geothermal power in their mixes, depending on the country (see chart). In the case of the Caribbean, composed mainly of SIDS (Small Island Developing States), land scarcity poses a relevant technical challenge for development of renewable energy resources, both conventional and non-conventional. While the Central America and Caribbean region's GHG emissions are marginal on a world scale, there is considerable room for mitigating emissions via natural gas.

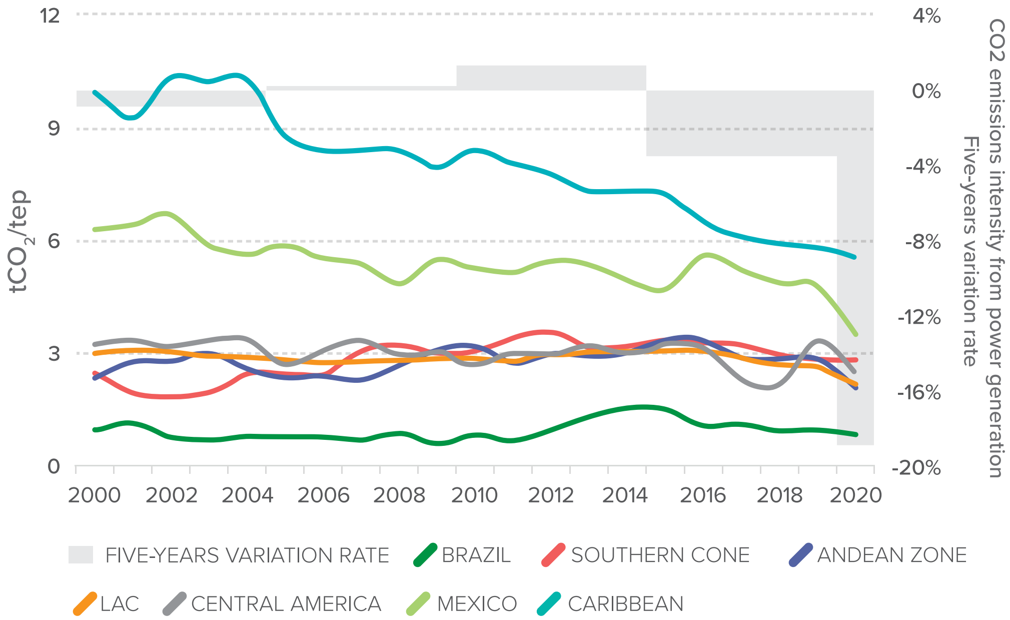
Caribbean Energy Supply
by Source

Source: OLADE



CO_2 Emissions Intensity from Power Generation in Latin America and the Caribbean

Source: OLADE



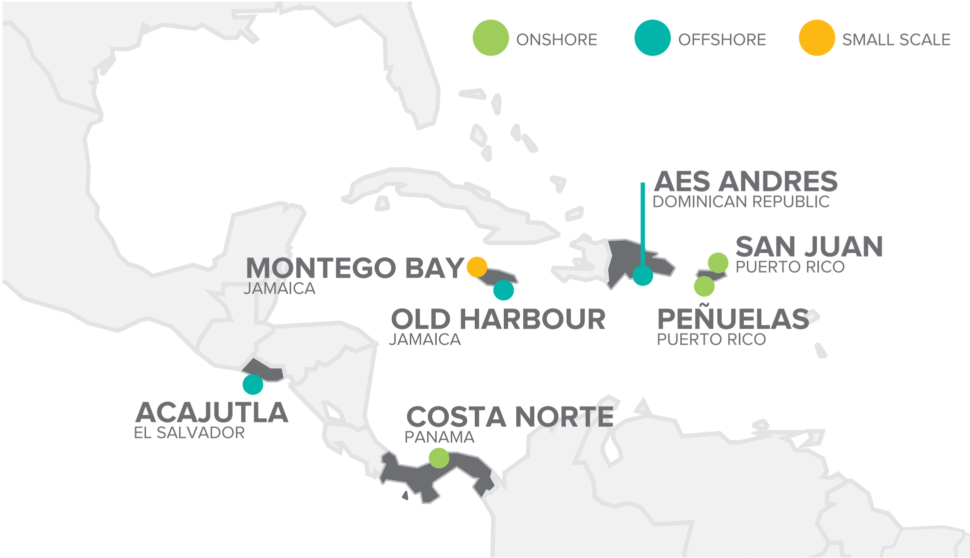
Essentially, the opportunity for natural gas lies in the substitution of more polluting fuels in the power generation and transport sectors, where short distances could be an advantage for infrastructure development. Some countries have already advanced in that direction. Puerto Rico was the first country in the region to build an LNG importing terminal (Peñuelas) in 2000. Since then, importing terminals have been built in the Dominican Republic (AES Andres), Jamaica (Montego Bay and Old Harbor), Panama (AES Colon), El Salvador (Acajutla), Nicaragua (Puerto Sandino — under construction), and a second terminal has been built in Puerto Rico (San Juan). Most of these projects were LNG-to-power (i.e., anchored in a thermal power station) and opened opportunities for other businesses. According to the GECF[1], some other countries in the Caribbean, such as Antigua & Barbuda and Barbados, are small-scale LNG importers via ISO containers, which is an adequate solution for small, sparse, and modular demands. Proximity to the USA and Trinidad & Tobago, two of the largest LNG exporters, could be a favorable driver for developing LNG in the Caribbean.

The Panama Canal, as a natural hub for bunkering, together with the region's growing LNG infrastructure, opens up excellent opportunities to develop LNG for maritime transportation in line with the decarbonization commitments of IMO. LNG bunkers could reduce emissions in large vessels, which typically use very dirty and heavy oil derivatives.

Scaling up LNG investment in the region could help mitigate GHG emissions, mainly in power generation, land transport, and bunkering, while improving energy security.

LNG Terminals in Central America and the Caribbean

Source: IGU

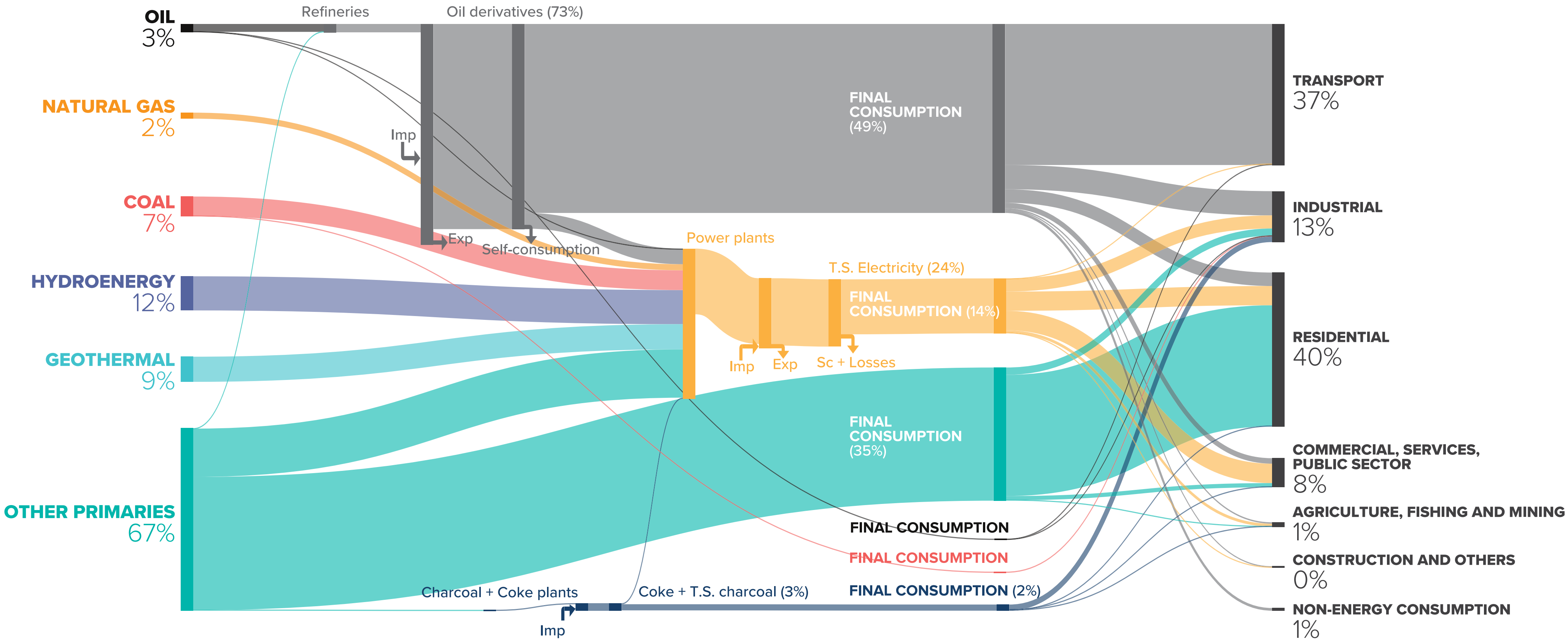


COUNTRY	TERMINAL	START YEAR	NAMEPLATE RECEIVING CAPACITY (MTPA)	TYPE
Dominican Republic	AES Andres	2003	1.9	Onshore
El Salvador	Acajutla	2022	2.3	Floating
Jamaica	Old Harbour	2019	3.6	Floating
Jamaica	Montego Bay	2016	0.5	Onshore
Mexico	Energía Costa Azul	2008	7.6	Onshore
Mexico	Pichilingüe	2021	0.8	Onshore
Mexico	Altamira	2006	5.4	Onshore
Mexico	Manzanillo	2012	3.8	Onshore
Panama	Costa Norte	2018	1.5	Onshore
Puerto Rico	Peñuelas	2000	1.2	Onshore
Puerto Rico	San Juan	2020	0.5	Onshore

[1] According to the GECF(1), some other countries in the Caribbean, such as Antigua & Barbuda and Barbados, are small-scale LNG importers via ISO containers, which is an adequate solution for small, sparse, and modular demands. Proximity to the USA and Trinidad & Tobago, two of the largest LNG exporters, could be a favorable driver for developing LNG in the Caribbean.

Energy Balance: Central America - 2021
Total Energy Supply: 39,571 ktep

Source: OLADE



COUNTRIES' INSIGHTS

Chile

Natural gas to accelerate coal phase-out

Climate objectives

The COP25 Presidency of Chile in December 2019 represented a turning point in the strengthening of climate policies in Chile. The result was underscored in April 2020 with a new version of the NDC target, replacing the previous emission intensity indicator, (reduction of CO_2 emission per gross domestic product by 30-45% below 2007 levels by 2030), with absolute indicators, a goal of 95 Mt of CO_2e by 2030, with the objective of an emissions maximum in 2025, and a GHG emissions budget of no more than 1,100 Mt of CO_2e in the period 2020-2030.

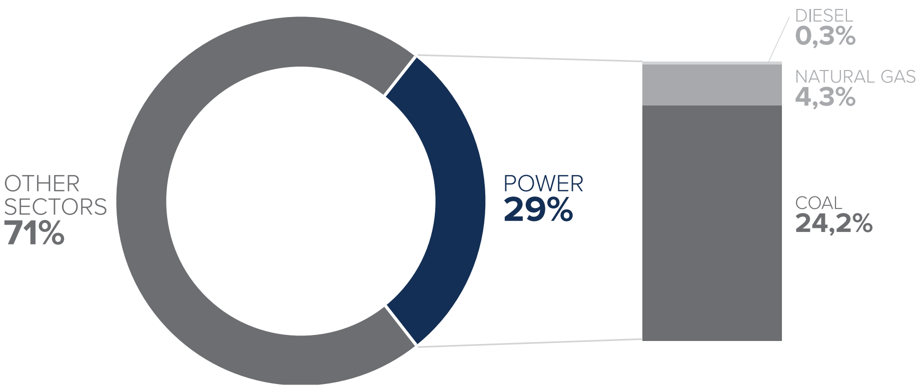
This stimulus was capitalized with the publication of the Climate Change Framework Law (Law 21455, Congreso Nacional de Chile, 2022)[1] and introduction of a legally binding carbon neutrality in 2050 target.

In March 2022, the updated Energy Strategy (PEN) included a new ambition of a renewables share of 80% in 2030 and 100% in 2050. However, the increasing number of bankrupt renewable projects in Chile in 2021 and 2022 may result in some changes in the regulated auction framework. There are two regulated auctions scheduled for 2023: one for supply starting in 2027 and the other in 2028.

Chile contributes 0.2% of global GHG emissions, with power generation responsible for 29% of the country's emissions[2]. Natural gas represents 4.3% of the country's total emissions, well below the 24.2% generated by coal. The transport sector, which mainly relies on diesel-powered light and heavy vehicles, contributes 25%[3].

GHG Chilean emissions

Source: energiE with data MMA



Chile's GHG emissions have increased in the last decades, in particular with a remarkable 118% increase in CO_2 emissions since 1990.

[1] Available: https://www.bcn.cl/leychile/navegar?idNorma=1177286.
[2] Source: Ministerio del Medio Ambiente. (2021). Informe del Inventario Nacional de Chile 2020: Inventario nacional de gases de efecto invernadero y otros contaminantes climáticos 1990-2018. Oficina de Cambio Climático. Santiago, Chile. Available: https://snichile.mma.gob.cl/Documentos/, PDF, XLSX. Global data: Climate Watch. 2022. Washington, DC: World Resources Institute. available: https://www.climatewatchdata.org/ghg-emissions.
[3] https://snichile.mma.gob.cl/wp-content/uploads/2022/06/Inventario_Nacional_de_GEI-1990-2018.xlsx.

Gas Sector Current Assets

There are currently two LNG regasification terminals in operation in Chile, the Quintero terminal and the Mejillones terminal, whose design capacities are shown below.

Design Capacity of LNG Terminals

Source: GNL Quintero, GNL Mejillones[4]

TERMINAL	REGASIFICATION CAPACITY [Million m^3]	LNG STORAGE CAPACITY [m^3 LNG]
GNL Mejillones	**5.5**	**187,000**
GNL Quintero	**15.0**	**334,000**

GNL Quintero has a project to expand its storage and regasification capacity that will help provide greater security and resilience to the energy matrix.

The project consists of the installation of a new 5 Mm3/day vaporization train that will increase the terminal's capacity to 20 Mm3/day, with an estimated investment of US$63 million. In addition, a new 160,000 m3 tank is being built to replace the smaller tank, at a cost of US$200 million.

Electricity Sector

The Chilean electricity sector is one of the most liberalized in the region, with a high degree of private participation.

Since the Paris Agreement (2015), Chile has added more new coal (+927 MW) and diesel (+744 MW) generation to its electricity portfolio than CCGT plants (+670MW), while gas emissions are considerably lower.

Additionally, **historical data shows that thermal generation has been maximizing the coal load factor vs the gas load factor in the last decade and, even now, this has not responded to the relative competitiveness of coal or gas in the international markets, (cycles where gas has been more competitive than coal).** This remarkable fact comes from the long-term commitments of the coal power plants (PPAs of coal power plants, long-term supply), which limit the decarbonization of the economy and lead to an under-utilization of the CCGT plants. As a result, coal is the country's main source of electricity, followed by hydro and natural gas.

Penetration of renewables has displaced liquid fuel-fired generation. **As Chile is not a coal producer, the switch from coal to gas should be prioritized and incentivized in the short-to-mid-term.** CO_2 market-based approaches, such as Emission Trading Schemes (ETS), are effective ways to incentivize new climate-friendly investments in renewable capacity, as well as, the encourage of exiting thermal generation with fewer emissions.

[4] https://www.gnlquintero.com/
https://www.gnlm.cl/

The coal phase-out program will unlock additional space for renewables and natural gas. A voluntary agreement was signed in 2019[5] between the Chilean government and the four largest power producers, Engie, Colbún, Enel, and AES Andes, to substitute coal-fired power generation by 2040. The roadmap has been modified several times.

As of today, it is expected that 2.0 GW of coal generation will be phased out before 2030, with 1.5 GW of this decommissioned before 2025. Nevertheless, 1.7 GW of coal generation does not have any scheduled decommissioning date.
The newest coal power plant, IES, commissioned in 2019, will be upgraded to natural gas by 2025.

It is worth mentioning that the most recent official schedule for the closure and conversion of coal-fired power plants published by the CNE, corresponding to the one used for the preparation of the Definitive Technical Report on the Short-Term Node Price 2022-02, considers the complete closure of operations of the Puchuncaví coal-fired complex –that is, the Nueva Ventanas and Campiche power plants– for the month of April 2029. This date coincides with the expected start-up of the HVDC Kimal-Lo Aguirre Line, considered by the CNE for May 2029 according to the Decree of Adjudication of said work.

Finally, this expected decommissioning date is 4 years after what was announced by AES Andes, that is, leaving the Nueva Ventanas and Campiche units available for early retirement, starting in January 2025. And at the same time, 3 years after the one considered in the ACERA study, which contemplates the withdrawal of Campiche and Nueva Ventanas by January 2026.

Estimated Phase-out and Retrofitting of coal-fired power plants

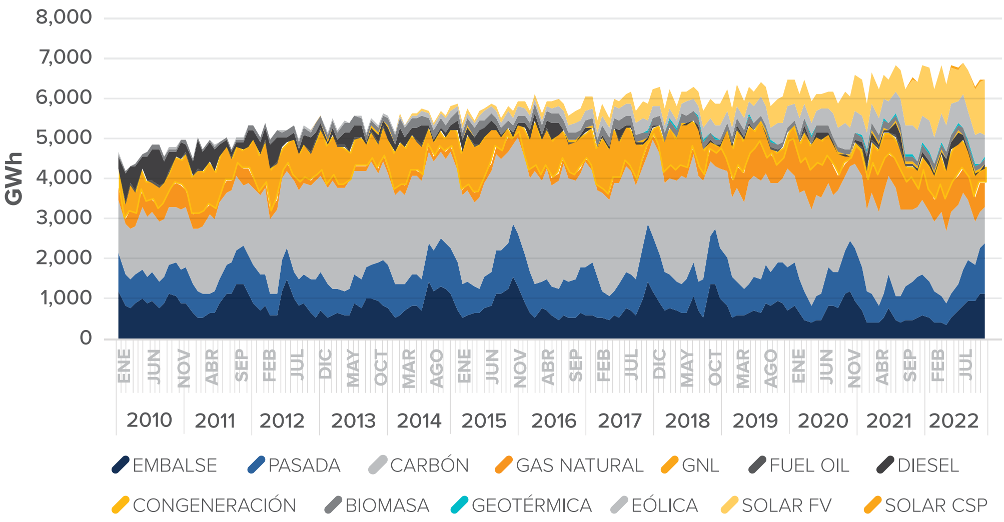
Source: energiE based on public information CEN, CNE, and industry players

COAL – FIRED POWER PLANT	INSTALLED CAPACITY [MW]	CATEGORY	ANNOUNCEMENT
Ventanas 2	154	Phase out	Dec-22
Mejillones CTM1	135	Phase out	Dec-24
Mejillones CTM2	138	Phase out	Dec-24
Angamos 1	230	Phase out / Retrofitting	Apr-25
Angamos 2	234	Phase out / Retrofitting	Apr-25
Andina CTA	177	Retrofitting	Aug-25
Hornitos CTH	151	Retrofitting	Aug-25
IEM	331	Retrofitting	Dec-25
Campiche	242	Phase out	Dec-26
Nueva Ventanas	238	Phase out	Apr-29
Subtotal	**2.030**		
Cochrane 1	233	TBD	TBD
Cochrane 2	233	TBD	TBD
Guacolda 1	136	TBD	TBD
Guacolda 2	129	TBD	TBD
Guacolda 3	138	TBD	TBD
Guacolda 4	140	TBD	TBD
Guacolda 5	138	TBD	TBD
Nueva Tocopilla 1	122	TBD	TBD
Nueva Tocopilla 2	118	TBD	TBD
Santa María	308	TBD	TBD
Subtotal	**1.695**		
TOTAL	**3.725**		

[5] "Plan de phase out y Retrofitting de Unidades a Carbón". Chilean Government

Electricity Generation by Source
(GWh)

Source:
"Comision Nacional de Energia"
CNE [6]

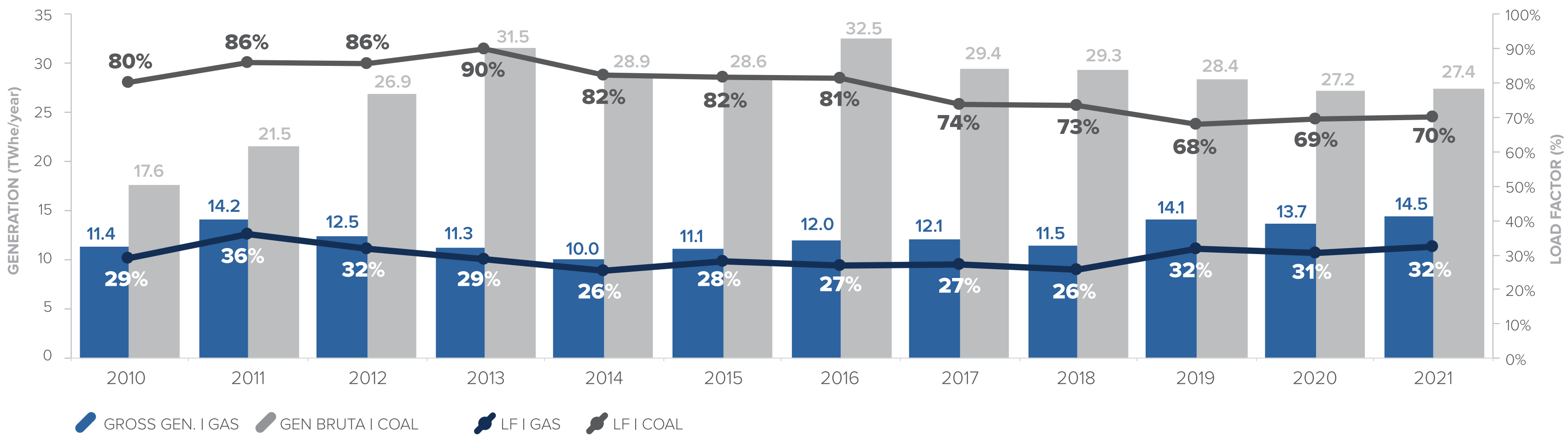


What are the main risks and bottlenecks of the current electricity sector in Chile?

- Hydro inflows have been consistently under the long-term average since 2008, pushing reservoirs to operate continuously at low-level. This creates more uncertainty and risk of worsening the carbon footprint of the power sector.
- The PPA contracts signed by coal power generators that can limit the coal-phase out programme.

Production and Load Factor
(Natural gas and coal thermal units)

Source: ENERGIE calculations, based on CNE data[7]



[6] https://www.cne.cl/normativas/electrica/consulta-publica/electricidad/
https://infotecnica.coordinador.cl/instalaciones/unidades-generadoras
[7] https://www.cne.cl/normativas/electrica/consulta-publica/electricidad/

Copper

Mining is at the core of the discussion on how to manage the transition to a low-carbon economy. Renewable power generation, the retrofit and expansion of the power grid worldwide to accommodate more renewable demand, as well as electric vehicles, are much more copper intensive.

According to the "Informe Comercio Exterior de Chile, Subsecretaría de Relaciones Economicas Internacionales del Gobierno de Chile"[8], copper exports represent 79% of the country's mining exports, and 44% of the country's total exports. As the heartland of Chilean economy Chile is the leading copper production country in the world, with 28% share of copper deposits, followed by Peru with 13%. However, the copper refining process is led by China, which refines 40% of the world total.

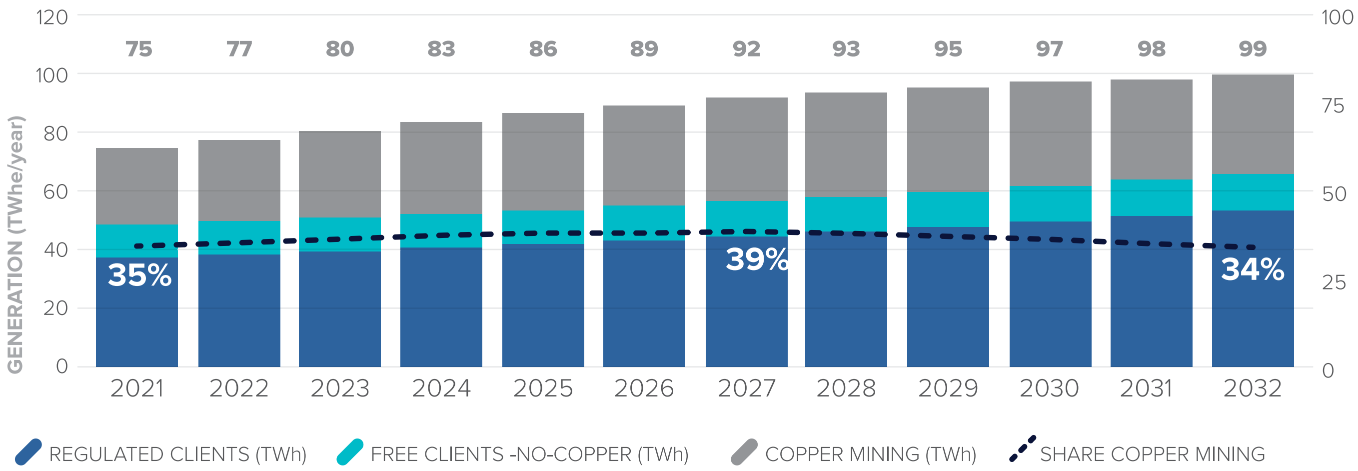
However, the copper market faces several challenges in the coming years. As highlighted by the IEA in the Sustainable Development Scenario [SDS])[9], demand could rise by over 40% over the next two decades, leaving a supply/demand gap of between 20% and 40%. Declining copper quality (in Chile the decline has been by 30% over the past 15 years) and extraction of copper from deeper reservoirs, is translated into major energy use increased GHG emissions and water stress, at a time when rising ESG requirements on copper producers are affecting access to capital.

Orderly energy transitions in the mining sector, taking a realistic and pragmatic approach and improving fulfilment of ESG requirements, implies an initial investment in decarbonization of energy sources needed for copper extraction and manufacture. The copper industry in Chile is the country's biggest power client, with a share of 37% of the overall power demand. This is followed by the energy consumption of the heavy diesel vehicles needed for its transport.

As mentioned before and according to CNE figures, share of coal participation in the Chilean power mix has reached 32%, followed by hydro (20%) and natural gas (18%). And if we also take into account China, as the principal copper refiner with energy generation that is 60% coal fired, **copper's carbon footprint is highly dominated by GHG** emissions Consequently the current commitments with coal phase out of Chile in 2040 and coal phase-down of China in 2060 could be discussed. The urgency to incentivize and advance these horizons, to decarbonize the economies with decarbonized materials.

Estimated Electricity Consumption by Type of Client
Domestic Market

Source: ENERGIE calculations, based on CNE data



[8] https://www.subrei.gob.cl/
https://www.iea.org/data-and-statistics/charts/coal-capacity-by-type-in-the-sustainable-development-scenario-2010-2030
[9] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary

COUNTRIES' INSIGHTS

Colombia

A committed industry, innovative opportunities, and supply challenges

Climate objectives

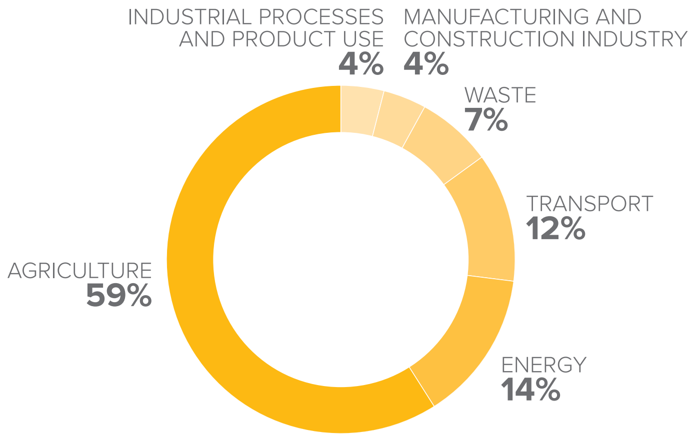
Colombia issued its NDCs in 2020 and committed to an absolute goal of producing less than 169.44 Mt of CO_2e in 2030; a 51% reduction compared to the base scenario. It aims to peak emissions between 2027 and 2030, and to drive carbon neutrality by 2050. It also committed to reducing black carbon emissions to 40% of 2014 levels[1].

The natural gas industry in Colombia is committed to decarbonization, as stated in the multi-sectoral agreement signed during COP26 in Glasgow in 2021[2]. It also committed to contributing to meet the aspirational goal of the Global Methane Pledge, which aims to reduce global methane emissions across all sectors by at least 30% below 2020 levels by 2030[3]. Reducing fugitive emissions, gas flaring, introducing low carbon technologies such as hydrogen, biogas and biomethane, and compensating projects are some of the actions the industry is taking in that direction.

As in many Latin American countries, burning fossil fuels for energy use is not the main source of GHG emissions, representing 26% of Colombia's total. Transport accounts for 12% of GHG emissions and energy 14%, while Agriculture, Forestry, and Land Use (AFOLU) represent 59%[4].

GHG Emissions by Sector - Colombia
(share of CO_2 equivalent)

Source: Ministry of the Environment and Sustainable Development



Socio economic

Colombia's economy relies heavily on the fossil fuel industry. **Coal and oil made up an average of 51% of exports in the last five years[5], and the sector as a whole represents more than 5% of GDP[6] and a significant share of fiscal incomes and direct foreign investment, among other key socio-economic indicators.** In 2020, the total contribution of oil and gas companies to fiscal income was US$3.1 billion, a figure equivalent to 9% of the current income of the central government. If fuel taxes are included, the fiscal contribution of the hydrocarbon chain in 2020 was US$4.4 billion, equivalent to 12% of the current income of the central government.

Colombia's natural gas value chain represents 1% of GDP, employs more than 100,000 people, and transfers around US$2.5 billion per year in royalties to the central government. Natural gas represents 21% of the country's total primary energy supply[7], and the National Energy Plan, issued by the Mining and Energy Planning Unit (UPME) in 2021, estimates that this share would be in the range of 16%-25% in 2050, depending on the scenario considered[8].

Colombia's natural gas value chain

1% of GDP

100,000 jobs

transfers
2,500 million USD/year
to the government

[1] https://unfccc.int/sites/default/files/NDC/2022-06/NDC%20actualizada%20de%20Colombia.pdf.
[2] Naturgas (2021). Comunicado de Prensa "Industria de gas natural firma alianza por la carbono neutralidad". Publicado en la web de Naturgas el 3 de noviembre de 2021.
https://naturgas.com.co/industria-de-gas-natural-firma-alianza-por-la-carbono-neutralidad/
[3] https://www.globalmethanepledge.org/
[4] Naturgas (2022). Informe Indicadores 2021. p. 47
[5] According to DANE, the figures in 2022 (59% oil and 25% coal) surpass the five- year-average.
[6] DANE (Departamento Administrativo Nacional de Estadística) Colombian Government: https://www.dane.gov.co/index.php/estadisticas-por-tema/comercio-internacional/exportaciones.
[7] Promigas, 2022, p.37).
[8] UPME (Unidad de Planeación Minero Energética), 2019. Plan Energético Nacional 2020-2050. https://www1.upme.gov.co/DemandayEficiencia/Paginas/PEN.aspx.

Natural gas

Domestic demand and supply challenges

Colombia and Argentina are the two countries in Latin America that have attained mass coverage of natural gas services. There are more than 10.5 million residential users in Colombia, benefiting 36 million people, most of them (85%) in the poorest economic quintiles[9]. Natural gas also provides 12% of the primary energy supply for power generation[10], 16% for the industrial sector[11], and 1.5% for the transport sector with around 280,000 vehicles running on natural gas (NGVs). Given that the transport sector is one of the most carbon intensive, many opportunities exist for decarbonization.

In terms of supply, natural gas domestic production averaged 52 Mm3/d [12] and supplied 98% of consumption[13]. The only active importing infrastructure is an LNG terminal located offshore Cartagena, which provides gas to three thermal power plants on the Caribbean Coast in the northeast of the country. The main role of this terminal is to back up the intermittency of renewable energy supply; particularly in the case of severe drought associated with the recurrent El Niño phenomena.

The fact that virtually all natural gas consumed in the country is produced domestically safeguards Colombia from the volatility of international markets. Natural gas is traded at around US$4-5/Mbtu[14]; however, this situation might change if there is not enough investment in E&P.

Current proved reserves are estimated at 3.1 tcf, and the R/P ratio is about eight years. Adding probable and possible reserves raises this figure to 4.5 Tcf and 11 years of gas self-sufficiency. The total reserve potential is 60 Tcf[15]. Recent large discoveries, mainly offshore in the Caribbean Sea, could extend the reserves horizon, but offshore projects take a while to develop, so these reserves should be relevant in the mid term. In the short term, investments in E&P are needed because of energy security and affordability.

Users

10.5 million
residential users

36 million people
most of them (85%) of the poorest income quintiles

Trade

Natural gas is traded at around
4-5 USD/mbtu

Current proved reserves

3.1 tcf
R/P ratio ≈ 8 years

Adding probable and possible reserves raise to
4.5 tcf
11 years of gas self-sufficiency

Total reserve potential
60 tcf

[9] Promigas, 2022, pp.54-55.
[10] Naturgas, 2022, Informe Indicadores 2021. p.38
[11] IEA, Sankey Diagrams, Online resource, accessed January 2023. https://www.iea.org/sankey/.
[12] Agencia Nacional de Hidrocarburos, 2022, Producción Fiscalizada Gas 2022. https://www.anh.gov.co/es/operaciones-y-regal%C3%ADas/sistemas-integrados-operaciones/estad%C3%ADsticas-de-producci%C3%B3n/.
[13] Naturgas, 2022, Informe Indicadores 2021. p.39
[14] Naturgas (2022). Gas natural pieza clave para hacer de Colombia potencia mundial de la vida. p.17
[15] Naturgas (2022). Gas natural pieza clave para hacer de Colombia potencia mundial de la vida. p.17

Transport

The transport sector's share of total GHG emissions is 12%[16]. According to Naturgas, NGVs are more competitive than traditional fuel vehicles. Regarding emissions, the Transmilenio success story — a passenger bus company in Bogotá which converted part of its fleet to natural gas — showed that the use of natural gas-fueled vehicles reduced the company's CO_2 emissions by 50% and reduced other air pollutants[17]. Today, more than 4,000 heavy-duty vehicles run on natural gas, but there is still a lot of room for development and decarbonization in this area. The high geographical coverage of natural gas supply is a key advantage to leverage investments in the transport sector.

Share of total GHG emissions
12%

Transmilenio - Bogotá
natural gas-fueled vehicles
reduced the company's CO_2 emissions by
50%

+ 4,000 heavy-duty vehicles
run on natural gas

Renewable Gases

There is also significant potential to develop hydrogen, biogas, and biomethane for different uses like cooking, transportation (public buses and cargo), energy production, and storage. Biogas and biomethane have potential in rural areas of Colombia, where traditionally the gas industry has not had a presence. More than 5.3 million mostly poor people, or 1.7 million families, still cook using highly inefficient and polluting fuels, such as wood or charcoal. Also, small and medium cities are growing and developing transport systems, where the use of renewable gases could help to achieve the black carbon reduction goal committed to in the NDCs.

1.7 million families
cook using highly inefficient and polluting fuels

[16] IDEAM, Fundación Natura, PNUD, MADS, DNP, CANCILLERÍA (2021). Tercer Informe Bienal de Actualización de Colombia a la Convención Marco de las Naciones Unidas para el Cambio Climático (CMNUCC). IDEAM, Fundación Natura, PNUD, MADS, DNP, CANCILLERÍA, FMAM. Bogotá D.C., Colombia. ISSN: 2805-8232 (En línea).
[17] Presentation by Rodolfo Anaya, CEO Vanti Group, at the International Gas Conference, 2022

COUNTRIES' INSIGHTS

Ecuador

Natural gas for the transition of
a traditional oil producing country

Current situation: Economy, emissions, and energy

Economy

Ecuador, located on the Pacific Coast of South America, has a territory of **283,561 km²**, and a population of 17.8 million. Its main geographical features are the rainforest, which covers around 45% of the surface area, mainly concentrated in the Amazon rainforest in the eastern part of the country; the Andean range in the center (La Sierra), with mountains and volcanos exceeding 6,000 meters; and the coast, in the western part of the country. Almost 95% of the inhabitants live on the coast or in the La Sierra region, with only 5% living in the Amazon rainforest region.

According to the World Bank, Ecuador GDP per capita in 2021 was US$5,965 (current US$), and it ranks 95th in the UN Human Development Index ranking, with an HDI value of 0.74, which is considered high.

The economy grew steadily between 2000 and 2015, boosted by the commodities boom and the high oil price cycle, among other factors. The country´s economy relies mainly on oil exports, agricultural products such as bananas, flowers, and fisheries. **Ecuador produces almost 500,000 barrels of crude oil daily, of which more than 70% is exported. Oil exports represented 24% of the country's total exports in 2020 and 27% in 2021[1], and fiscal incomes from oil E&P were 9.2% and 5.8% in 2019 and 2020 respectively.[2].** On the other hand, significant quantities of **oil products are imported, accounting for 13% of total imports[3]**.

2021

Oil Exports
27%
of total exports

Fiscal incomes from oil
5.8%
of total

Oil products Imports
13%
of total imports

[1] OEC World. https://oec.world/en/profile/country/ecu
[2] OECD (2022). Revenue Statistics in Latin America and the Caribbean 1990-2020
[3] OEC World. https://oec.world/en/profile/country/ecu

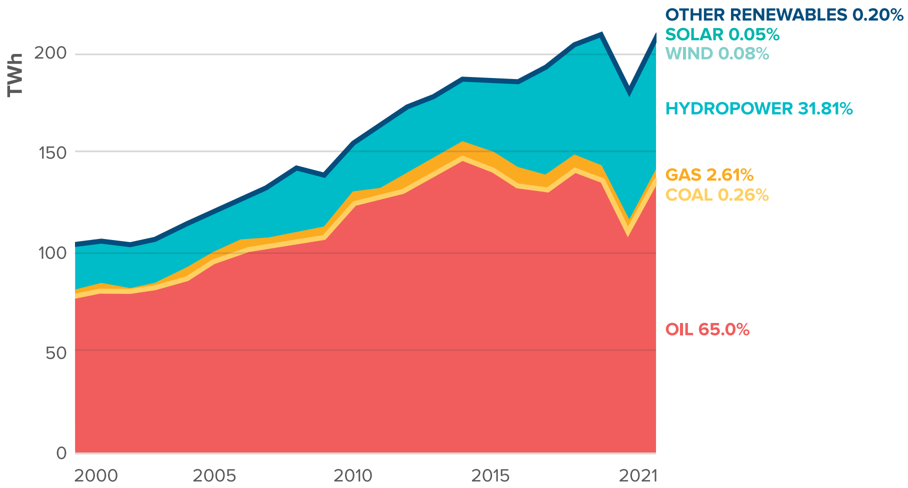
Emissions and energy

According to Ecuador´s 1st NDC (2019), 47% of GHG emissions come from using energy, 25% from land use, land-use change, and forestry (LULUCF), 18% from agriculture, 6% from industrial processes and product use (IPPU), and 4% from waste. In the same document, the country committed to reducing 9% of CO_2 emissions (unconditional) and 20.9% (conditional) by 2025 in the energy, agriculture, industrial processes, and waste sectors, compared with a reference scenario with 2010 as the base year. It also committed to reducing 4% (unconditional) and 20% (conditional) in the LULUCF sector, with 2000-2008 as the reference level. The main lines of action defined in the energy sector are promoting renewable energy, energy efficiency, behavioral change, and sustainable mobility.

The primary energy source is oil, with a share of 65%, mainly imported oil products for transport, power generation, and industry. Hydropower is the primary source of electricity generation, representing 79% of the total mix. However, 13% of electricity is still generated from oil products.

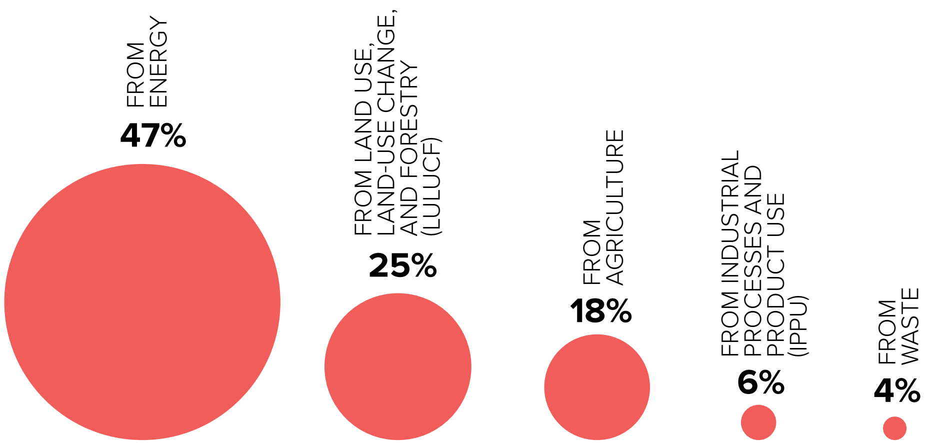
Energy consumption by source

Source: Our World in Data
https://ourworldindata.org/energy/country/ecuador



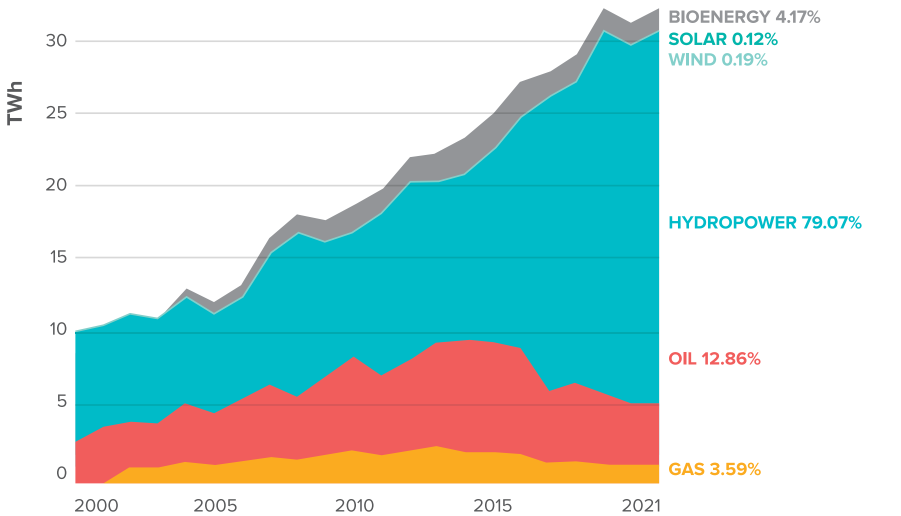
GHG Emissions by sector

Source: 1st NDC



Electricity production by source

Source: Our World in Data
https://ourworldindata.org/energy/country/ecuador



Natural gas

Natural gas is marginal in Ecuador´s energy mix, representing less than 3% of the total share. However, there is room for development, substituting imported (and subsidized) oil products for transport, power generation, and industry.

Supply

Campo Amistad

Natural gas is supplied from Campo Amistad, a non-associated gas field located 65km offshore the Guayaquil Gulf. Current production is around 600,000 m3, fueling a thermal electricity generation plant in Machala. Production has been declining from a peak of 1.6 million m^3/d in 2014.

LNG

An onshore ISO container LNG import terminal has been built in the same area, operated by Sycar, representing another source of natural gas supply.

Associated gas

Associated gas from the oil fields in the Amazon rainforest is used to fuel on-site operations, avoiding methane emissions.

Demand

While there is potential for developing natural gas demand in Ecuador, improving natural gas supply and competitiveness are the main challenges.

The two sectors with the most potential for development are electricity generation and industry.

Electricity generation

Demand for electricity and energy has grown rapidly in the last two decades and is expected to continue growing in the coming years, putting pressure on the supply side and potentially increasing the demand for oil products for power generation. While hydropower is the primary source of electricity generation, thermal backup is needed mainly during the dry season.

There is potential to develop efficient gas-fired power plants to substitute for inefficient plants using diesel and fuel oil, especially in the southern part of the country. There is also potential to develop renewable energy, helping to decarbonise the electricity supply while reducing imports. In January 2023, the government awarded contracts for 511 MW of renewable energy (solar PV 317 MW, hydropower 149 MW, and wind energy 45 MW), with prices oscillating between US$45 and US$67/MWh.

Industry

Industry is estimated to have an equivalent potential demand for natural gas of around 3 million m^3 daily, concentrated in Quito, Guayaquil, and Cuenca. Switching to natural gas could help the country to reduce imports of oil products and fiscal costs.

COUNTRIES' INSIGHTS

Guyana and Suriname

Two carbon negative countries with outstanding untapped natural resources to overcome economic challenges

Two carbon-negative countries committed to rainforest conservation

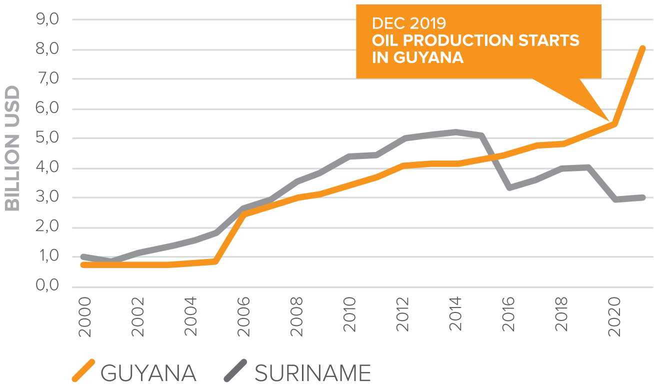
Both Guyana and Suriname are mainly covered by the Amazon rainforest, and because of their characteristics and conservation policies and practices, their forests sequester more carbon than these nations emit from other human activities and sources, being among a handful of countries that are net carbon sinks. **Guyana has the world's second highest percentage of rainforest cover (85%), only behind Suriname (91%);** both countries also have very low deforestation rates[1], and are committed to forest conservation in their NDCs and through different initiatives such as REDD++. **Guyana has 18.0 million hectares of forests, representing carbon stocks of around 21.8 Gt of CO_2[2]; while Suriname´s forests cover around 15.2 million hectares maintaining a carbon sink of 13.1 Gt of CO_2.**

Offshore discoveries, a key lever for two under-performing economies

Guyana and Suriname are the rising stars of oil and gas E&P in the region due to the high-potential offshore basin recently discovered.

Guyana and Suriname GDP
Current USD

Data Source:
World Bank (WDI Database)



Guyana's first oil discovery was made in 2015. Since then, more than 30 discoveries have been reported. The country produces approximately 400,000 barrels of light oil per day. However, oil output is expected to grow to 1.2 million barrels per day in 2027 and 1.7 million barrels per day by 2035, making it the world's fourth-largest offshore production country (source: Plata Energy). Striking oil led to a massive economic impact in the country, as Guyana's GDP grew 43.5% in 2020, 21.2% in 2021, and pending final figures it is expected to have grown 58% in 2022[3], despite Covid-19. Guyana, whose Human Development Index was 0.71 in 2021 (high-level)[4], has a unique opportunity to leapfrog in terms of economic development.

Suriname already produces around 16,500 barrels of oil per day (source: Staatsolie Annual Report 2021) from the Tambaredjo, Calcutta, and Tambaredjo-Northwest onshore oilfields in Saramacca District. However, the first offshore oil discovery was reported in 2020 in block 58; since then, different companies have announced many other promising discoveries. These fields have massive potential but are still in the appraisal and development phase. If the country finally develops these resources, an oil boom is expected to happen in the second half of the 2020s, mirroring neighbor Guyana. Oil and gas discoveries have vast potential to help the country develop its economy, which has been underperforming in the last few years and was heavily affected by the pandemic.

GUYANA

First oil discovery
2015

+30
discoveries reported

Guyana's GDP grew

2020
43.5%

2021
21.2%

expected to grow
2022
50%

Expected:

2027
1.2 million
barrels per day

2035
1.7 million
barrels per day

[1] NDCs of Guyana (https://unfccc.int/documents/497557) and Suriname, (https://unfccc.int/sites/default/files/NDC/2022-06/Suriname%20Second%20NDC.pdf).
[2] Guyana's Low Carbon Development Strategy 2030 (p.121) (https://lcds.gov.gy/wp-content/uploads/2022/08/Guyanas-Low-Carbon-Development-Strategy-2030.pdf).
[3] World Bank. Global Economic Prospects. January 2023, p.73. https://openknowledge.worldbank.org/server/api/core/bitstreams/254aba87-dfeb-5b5c-b00a-727d04ade275/content
[4] UNDP. Human Development Reports. HDI Dataset. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

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Natural gas monetization opportunities
Power generation and LNG

Power Sector

Natural gas availability would allow midstream and downstream projects to be developed in both countries, unlocking monetization opportunities while mitigating emissions, especially by substituting imported oil products for power generation. Currently, 98% of power generation in Guyana is oil-fired and 80% in Suriname (source: IEA Sankey Diagrams).

In the case of Guyana, in December 2022, the government signed a contract for the construction of the integrated natural gas liquids (NGL) plant and the 300 MW CCGT power plant at Wales, West Coast Demerara (WCD), Region Three (BNAmericas). The project will enable Guyana to switch from the imported heavy fuel oil currently used for most of its power generation to domestic natural gas supplied from the Stabroek Block, which is cheaper, cleaner, and more reliable (source: HESS).

A 200 km offshore pipeline is being built to bring the natural gas from the offshore wells to land. The combination of natural gas and renewables being developed in the country is estimated to have the potential to cut emissions from the power sector by 70%. The power sector, as is usually the case, could be the anchor to develop other natural gas markets such as transport or industry.

Guyana

Substituting imported oil products for power generation

98%

of the total share in this sector

Construction of:

300 MW

combined-cycle gas turbine (CCGT) power plant

200 km

offshore pipeline

Natural gas + renewables: estimated to cut emissions from the power sector by

70%

Suriname

Substituting imported oil products for power generation

80%

of the total share in this sector

LNG exports

The massive resources discovered could also lead to the development of LNG export terminals, both onshore and floating LNG solutions. Many factors would determine the potential for LNG exports, but the most important would be the assurance of long-term off-taking commitments that could leverage financial feasibility and infrastructure development. From a supply-side perspective, natural gas resource potential might be enough to meet long-term demand requirements.

COUNTRIES’ INSIGHTS

Mexico

Natural gas as a key enabler
for power and industry decarbonization

Economy

According to the World Bank, Mexico's GDP was US$1,273 billion in 2021 (World Development Indicators Database – current prices)[1], being the second largest economy in the region after Brazil. With a population of around 127.1 million people, Mexico's GDP per capita is estimated at US$10,045 (WDI – current prices), a little below the world's average[2]. Inequality and poverty are also very high. In 2021, the Gini index was 0.452; 37.4% of the population were below the poverty line, and extreme poverty was 9.2% (Cepalstat)[3].

Mexico's economy is highly reliant on the oil and gas sector. With oil production of around 1.9 million barrels a day, the country is the 12th largest oil producer in the world (BP)[4]. Most of this production is exported to the USA and other countries, making the country one of the largest crude oil exporters in the world. The E&P sector represented more than 3% of GDP (Statista)[5], accounting for around 16% of total government revenues in 2021 (US International Trade Administration)[6]. Mexico's R/P ratio is around eight years, but there are significant resources to be developed in the country. At the same time, it is a large importer of oil products and natural gas.

Population

127.1 million people

Below the poverty line
37.4 %

Extreme poverty
9.2 %

Mexico's GDP
2021
1,273 billion USD

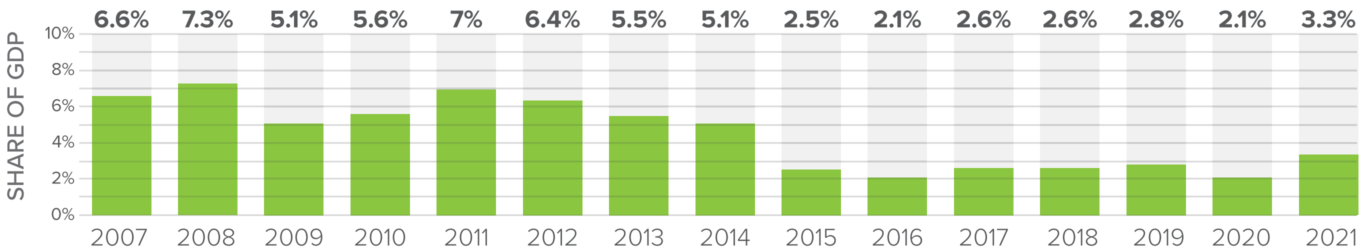
per capita
10,045 USD

Exploration and production sector represented
+ 3% of GDP
(Statista)
accounting for around 16%
of total government revenues in 2021

GINI index
0.452

Oil and gas extraction sector as share of gross domestic product in Mexico from 2007 to 2021

Source: Statista



[1] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=MX.
[2] https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.
World GDP/per capita: 12,234 US$/per capita.
[3] https://statistics.cepal.org/portal/cepalstat/index.html?lang=es.
[4] BP Statistical Review of World Energy.
[5] https://www.statista.com/statistics/1173837/gdp-share-oil-gas-sector-mexico/.
[6] https://www.trade.gov/country-commercial-guides/mexico-oil-and-gas.

Energy and Emissions

According to IEA, total primary energy supply in 2021 broke down as follows: natural gas 43.6%; oil 41.4%; biofuels and waste 4.7%; coal 4.2%; wind and solar 3.0%; nuclear 1.6%; and hydropower 1.6%. From a demand perspective, natural gas accounted for 55% of power generation, 31% of industrial power usage, 3% of residential/commercial/public sector usage, and a negligible 0.11% in the transport sector. Since the end of the 1990s, this share has grown steadily, allowing the country to replace more polluting fuel-oil, and reducing GHG emissions as a consequence.

Mexico has considerable renewable energy potential, in both wind and solar. However, while renewable energy has been growing in the last few years, there is a lot of room for development as there is still significant oil and coal power generation. It is likely that Mexico's energy mix will continue evolving towards natural gas and renewables. In the long term, comprehensive planning is needed to avoid stranded natural gas assets.

Total Primary Energy Supply (TPES) and demand by source
2021

Supply

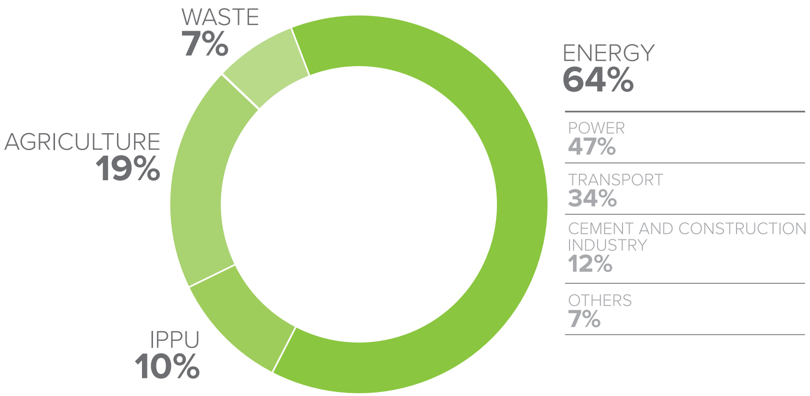
Natural Gas	Oil	Biofuels and waste	Coal	Wind and solar	Nuclear	Hydropower
43.6%	41.4%	4.7%	4.2%	3.0%	1.6%	1.6%

Demand

Power generation	Industrial power usage	Residential/commercial/public sector	Transport sector
55%	31%	3.0%	0.11%

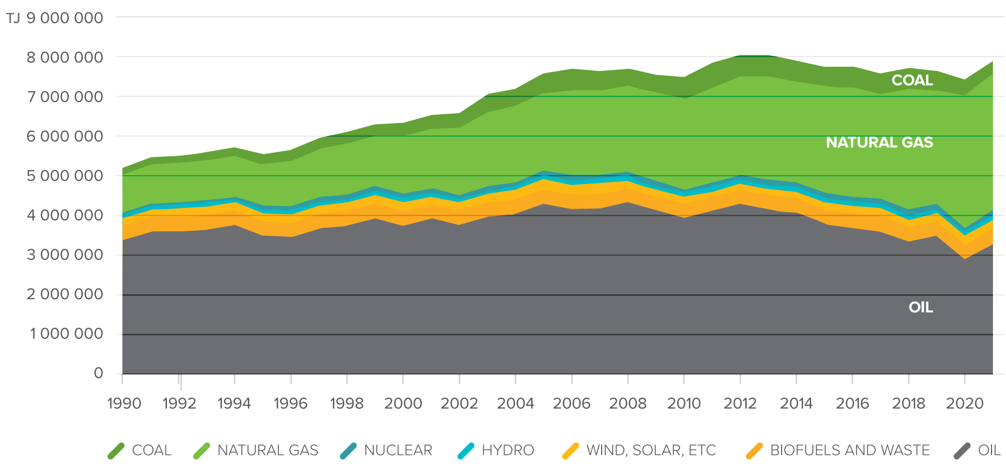
GHG Emissions by sector
CO_2e (%) I 2019

Source: IGHG Inventory (2022)



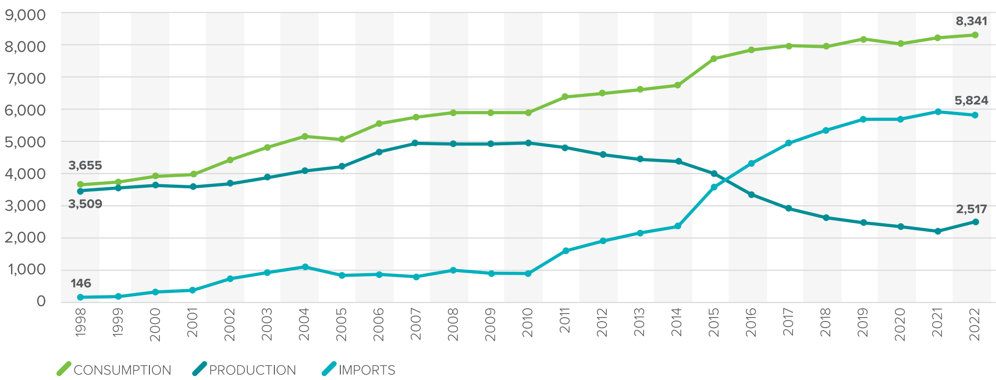
Total primary energy supply (TES) by source I 1990-2021

Source: IEA https://www.iea.org/countries/mexico



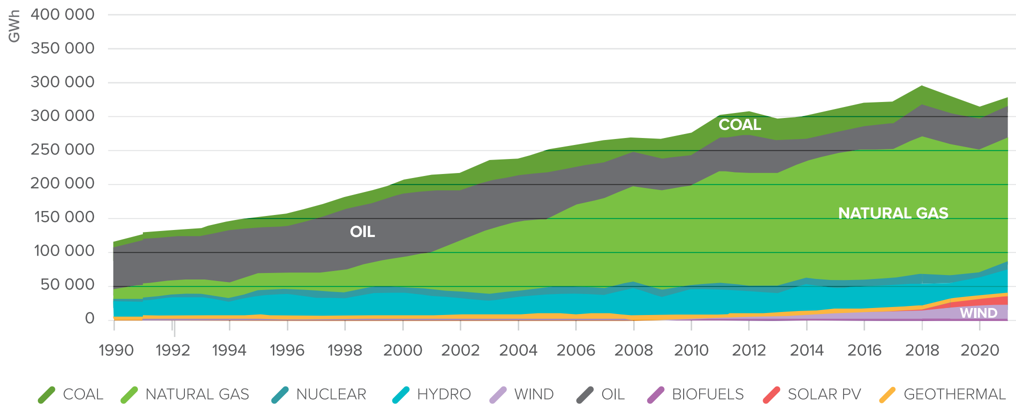
Natural Gas Production, Imports and Consumption
Mexico 1998-2022 / Million scf/d

Source: "Direccion General de Gas Natural y Petroquimicos", 2022



Electricity generation by source
Mexico 1990-2021

Source: IEA 2022



Natural gas, a synonym of industrial and economic development

The industrial sector is also very strong in Mexico, where secondary activities represent around 28% of GDP (INEGI). The country is an important supplier of manufactured products to the USA, where 80% of total exports are sent. Natural gas is used mainly in heavy and energy-intensive industries: chemical and petrochemical, iron, steel, and glass, among others. The fact is that economic development in Mexico is highly linked to the industrial sector and, by extension, to natural gas. In terms of energy intensity, and carbon footprint, heavy industries supplied by natural gas might assume a competitive advantage versus other countries whose energy mix is based on coal.

Natural Gas
+70% imported
mainly via pipelines from the US.

More than 70% of the natural gas used in the country is imported (SENER), mainly via pipelines from the USA, although Mexico also has LNG regasification terminals: Altamira on the country's Gulf Coast and Manzanillo and Energia Costa Azul on the Pacific Coast. When Mexico's own natural gas production started to decline in the first decade of the 2000s, the shale revolution was already taking place in the USA. Pipelines were built allowing Mexico to access the cheapest gas in the world, displacing domestic production and LNG imports. However, high dependence on a single supplier poses an important challenge to the country's energy security[7] while, at the same time, providing an opportunity to develop geological gas storage in depleted oil and gas fields.

A new opportunity: Exporting US natural gas via LNG to the Pacific Basin

The existing transport infrastructure, with access to the Pacific basin, where gas demand is more dynamic, opens new opportunities for the country too. There is currently one LNG export terminal under construction (Energía Costa Azul)[8] in Baja California, through the conversion of the LNG regasification terminal to a liquefaction facility. This project will bring US shale gas to the Asia-Pacific region. There are other liquefaction projects in Mexico under study, with the same goal of supplying gas to the Asian hubs.

In sum, Mexico is a success story of decarbonization of the power and industry sectors. They are complementary off-takers of natural gas, which has incentivized development of the gas infrastructure. Moving forward, natural gas should be the ideal partner for the development of renewable energy, while helping to decarbonize other regions. Energy security issues arise from dependence on the USA, highlighting interesting opportunities for Mexico to foster domestic production and investment in energy storage.

[7] Winter storm Texas 2021.
[8] The only liquefaction-export project in the world to reach a final investment decision in 2020.

COUNTRIES’ INSIGHTS

Peru

A successful case of boosting the economy while mitigating GHG emissions with domestic natural gas resources

Natural gas, a game-changer in the country

Peru is a great example of a country that has successfully developed natural gas resources, bringing great benefits to the economy while mitigating GHG emissions. Despite the fact that the natural gas industry has only two decades of history in the country, it has had a transformative impact.

As highlighted by OSINERGMIN[1], the Governmental Body for the Supervision of Mining and Energy, the commercial start-up of the Camisea Project in 2004 marked an important milestone in the economic history of Peru (Mendoza et al., 2021, p.18), transforming its energy industry. This is in line with Perupetro[2] remarks that the natural gas industry has contributed to an annual GDP growth of 4.37% in the last 20 years.

Economic Impact

Since the beginning of operations of the natural gas industry in Peru, royalties have been above US$10.2 billion. Fiscal incomes, including corporate income tax were estimated around US$21 billion in the same period (Mendoza et al., 2021, pp.129/131), allowing an increase in public investment and significant transfers to regional governments.

In terms of the external balance, Peru imported diesel, coal, and LPG for power generation, industry, households, and transport. But in 1998, Peru began its energy transition when, after natural gas discoveries, new policymaking decisions led to the replacement of diesel with natural gas in electricity generation. As of today, the country's power generation[3] is 56.8% hydro with a 37.6% natural gas back-up. The remainder of electricity generation is from renewable sources.

Since the development of Camisea, coal has been phased out, and the country has become a net exporter of LNG and LPG. Mendoza et al. (2021, p.133) estimate that the net benefit of the development of the natural gas industry in terms of the external hydrocarbons balance of trade has been around US$55 billion since

Royalties
above 10.2 billion USD

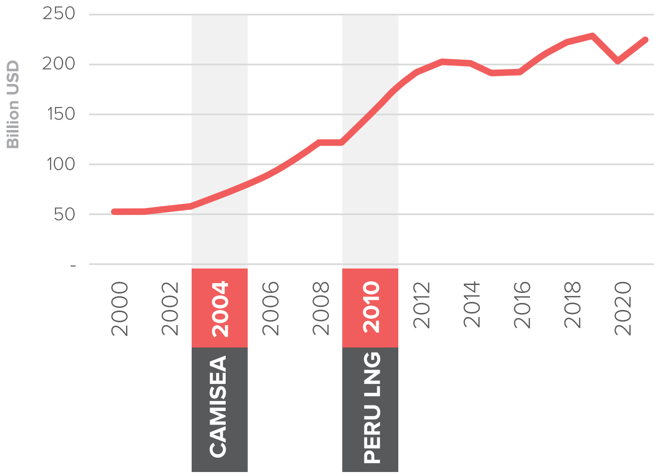
Fiscal incomes
around 21 billion USD

Camisea started operations. Peru became the first South American country to export LNG, when Peru LNG started operations in 2010 of a single-train liquefaction plant in Pampa Melchorita, with a liquefaction capacity of 4.45 Mtpa (IGU, 2022, p.103).

Regarding affordability, savings related to accessing a cheaper energy source have been estimated at a minimum of US$21 billion in all sectors since 2004[4].

GDP - PERU
Current USD

Data Source: World Bank (WDI Database)



Other estimates, such as the one made in a study by the local consulting firm Macroconsult, established that the Camisea project represented around 1.3% of GDP between 2004 and 2019, created more than 30,000 jobs, and contributed 4.3% of the country's exports in the same period[5].

[1] OSINERGMIN, Libro industria gas natural Peru, 2021.
[2] Perupetro, a state-owned company, has a mandate to promote, negotiate, underwrite, and monitor contracts for E&P of hydrocarbons in Peru.
[3] Electricity System Coordinator (COES). https://www.coes.org.pe/Portal/publicaciones/estadisticas/estadistica?anio=2021
[4] Mendoza et al. (2021). La industria del gas natural en el Perú.
[5] https://energiminas.com/macroconsult-camisea-genero-mas-de-30000-puestos-de-trabajo-en-15-anos/. I https://energiminas.com/macroconsult-camisea-entrego-al-peru-s-30-000-millones-por-ingresos-fiscales-en-ultimos-15-anos/.

External hydrocarbons balance of trade

around
55 billion USD

in the 15 years since Camisea started operations.

Savings allocated to accessing a cheaper energy source

at least
21 billion USD

in all sectors, since 2004

Camisea project represented

around
1.3% of GDP

between 2004 and 2019

+ 30,000 jobs

4.3% of the country's exports

Climate and energy impact

The main source of energy for power generation in Peru has been hydropower. However, prior to the discovery and development of natural gas resources, the thermal back-up was fueled by coal and oil products, with emission factors 122% and 90% higher than natural gas (Tamayo et al., 2014, p.200).

Natural gas discoveries helped the country to transition from diesel to natural gas for electricity generation, allowing the growth of electricity demand to be met. This would not have been possible to do with hydropower or other renewables because of the pace of growth or the unfeasibility of emerging technologies more than a decade ago. According to the power grid coordinator COES, in 2021, power generation was 56.8% hydro, with a back-up of natural gas in 37.6%[6], while the rest was covered with other renewable sources.

If natural gas would not have entered to the energy mix of the country

CO_2 Emissions from **coal and diesel thermal power plants** would have accumulated

98.8 million tCO_2
2004-2013

Actual CO_2 emissions

from **coal and diesel thermal power plants**

56.1 million tCO_2 = - 43%
2004-2013

Total avoided emissions, including industry and transport sectors

54 million tCO_2
thanks to natural gas adoption

No new estimates have been made since then; however, it is clear that the continuous use of natural gas in all these sectors in the last decade has helped the country to significantly mitigate GHG emissions. While there is no data, LNG exports should have helped to reduce emissions overseas. Moreover, the natural gas capacity for power generation already developed has given the country the flexibility to accelerate the adoption of other renewable energies. Natural gas abundance also opens great opportunities for GHG emissions mitigation in industry and transport, two hard-to-abate sectors.

[6] Based on COES Annual Statistics: Estadísticas Anuales (coes.org.pe).

Challenges for the natural gas industry in Peru

Natural gas resources development

The main opportunities for the natural gas sector arise from continuing to deepen the transformation, taking advantage of the massive natural gas resources that the country has.

From the supply side, the challenge is attracting investments to develop existing and well-known natural gas resources. From the demand side, the challenges come from continuing to develop external sector demand, while deepening the substitution of more polluting fuels in transport and industry.

Perupetro is dealing with proposals to shorten the permitting process, providing an detailed geological knowledge base to attract new E&P agreements (technical evaluation agreements).

Domestic demand (Gas for all)

The concept of "gas for the benefit of all Peruvians" has been part of the country's energy policies for the last few years, with the "Promotion of the *'Masificación'* of Natural Gas"[7] scheme; a public investment initiative to foster the construction of gas pipelines, seeking to speed the penetration of natural gas for domestic clients, and the industrial and automotive sectors. This was reinforced with some policies oriented to subsidize the access from households and transport conversions. The relevance of the natural gas was highlighted during 2022 with the Multisectorial Commission for the Massification of Natural Gas and the discussion of the bill to promote the massification of natural gas (Bill 679/2021-PE).

Additionally, the Peruvian Government has proposed the relaunching of the Southern Peru gas pipeline (on hold since 2016); a 1,000 km pipeline across the Andes mountains. It is worth adding that this challenging project could unlock underexplored reserves; as Peru has potential in both onshore and offshore basins. On the other hand, the impact on local communities is at the heart of the environmental permitting process, where there is a legal prior consultation requirement (The Law of Prior Consultation).

This systematic approach, with international standards and new ESG commitments, is part of Peru's new gas expansion. For this purpose, the example of other successful infrastructure models could be of value, for example the promotion of the natural gas grid in the EU under clear cost-benefit objectives and ensuring long-term ability to meet and stimulate a reasonable demand. Meanwhile, maintaining natural gas exports through Peru LNG benefits the country with positive international cashflows.

Transport

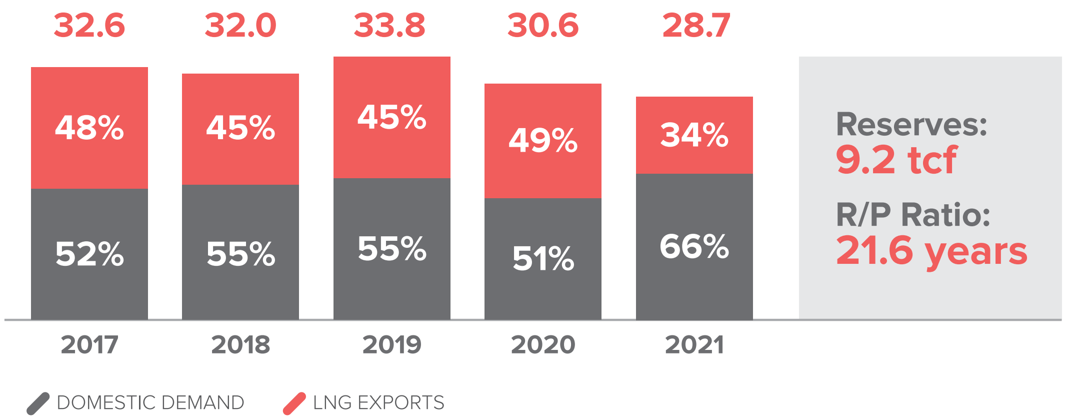
On the other hand, with regard to the **transport sector, Peru has a significant challenge to transform its aging fleet of diesel and gasoline vehicles by moving towards more environmentally friendly alternatives, where natural gas will have a critical role to play.**

The construction of the new transport and distribution infrastructure could be also instrumental to encourage the gas infrastructure for refueling vehicles.

[7] "Masificación": domestic demand, availability of the resource for all citizens.

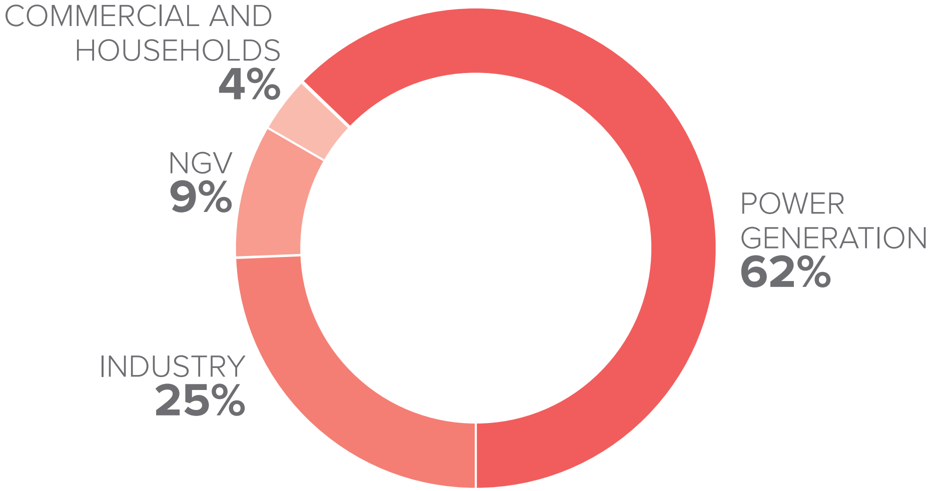
Natural Gas Demand
Million Cubic Meters per day

Source: Promigas
https://www.promigas.com/Paginas/Nuestra_Empresa/ESP/Informes-del-Sector-Gas-Natural-Peru.aspx



Natural Gas Domestic Demand
2021

Source: Promigas
https://www.promigas.com/Paginas/Nuestra_Empresa/ESP/Informes-del-Sector-Gas-Natural-Peru.aspx



Camisea gas transportation and distribution network

Source: Camisea Consortium

COUNTRIES' INSIGHTS

Trinidad & Tobago

A strong link among natural gas, ammonia, methanol and hydrogen

The critical role of Natural Gas in the Trinidad and Tobago Economy

Introduction

Despite being a small island country, Trinidad & Tobago is one of the largest natural gas producers in Latin America and the Caribbean, and its economy heavily relies on the production and export of natural gas and its derivatives (methanol and ammonia).

In 2022, Trinidad & Tobago was ranked second for global methanol exports and first for global ammonia exports.

According to the Government
Oil and Gas
forecast to account for approximately
30% of GDP
32% of exports[1] in 2022

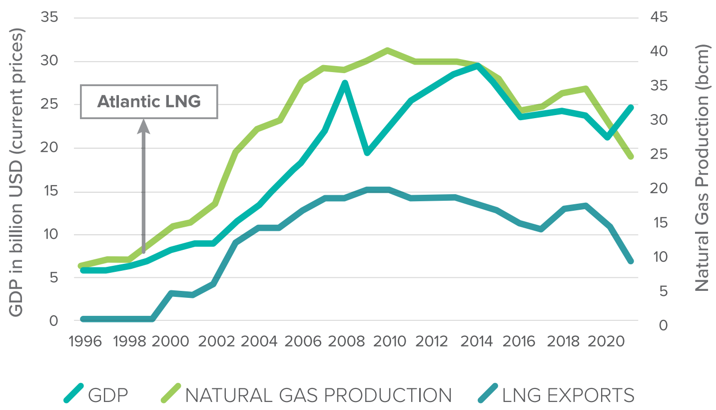
(source: CSO and Ministry of Finance).

According to the government and subject to final figures, oil and gas is expected to have accounted for approximately 30% of GDP and 32% of exports[1] in 2022 (source: CSO and Ministry of Finance).

On the subject of decarbonization, Trinidad & Tobago's intended NDCs, issued in 2018, aim to achieve a 15% reduction by 2030 in overall emissions from the three main emitting sectors (power, transport, and industry) under a business-as-usual scenario (BAU), which in absolute terms is an equivalent of 103 Mt of CO_2e[2]. (T&T intended NDC, 2018)

GPD and Natural Gas in Trinidad & Tobago

Data Source: World Bank (WDI Database) / BP Statistical Review of World Energy 2022



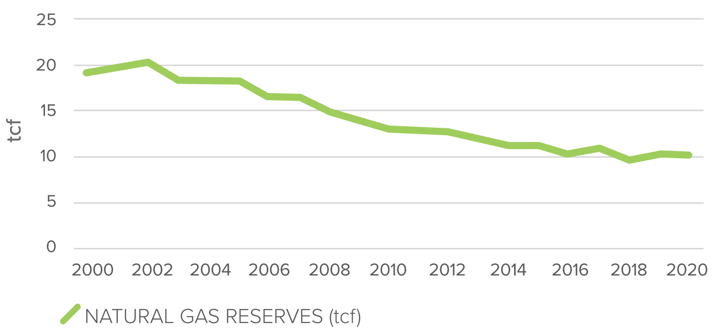
[1] https://www.finance.gov.tt/wp-content/uploads/2022/09/Review-of-the-Economy-2022.pdf.
[2] https://unfccc.int/sites/default/files/NDC/2022-06/Trinidad%20and%20Tobago%20Final%20INDC.pdf.

LNG Exports

Around 40% to 50% of the natural gas produced in the country is exported via Atlantic LNG, the very first LNG exporting terminal in the region which began operations in 1999 and which has a current liquefaction capacity of 14.8 Mtpa. In 2021, the country was the sixth largest LNG exporter of LNG to Europe, after the USA, Qatar, Russia, Algeria, and Egypt, accounting for about 2% of the region's total LNG imports. Trinidad & Tobago's LNG is especially important in the Spanish market, where it accounted for 5% of imports in 2021. Exports to Europe accounted for around 26% of total LNG exports in 2021, with exports to regional markets in Central America, the Caribbean, and Latin America being the most important with around 40% of exports. However, the situation in Europe brought significant changes to export destinations, and up to 40% of Trinidad & Tobago's LNG exports were delivered to Europe in the first half of 2022; a significant increase.

Natural Gas Reserves
tcf

Data Source:
BP Statistical Review of
World Energy 2022



Ammonia, Methanol and Industry

Natural gas industrialization is also key, as ammonia and methanol production are among Trinidad & Tobago's most relevant economic activities. Natural gas is not only the energy source used in this very energy-intensive industry, but also the feedstock for hydrogen production and synthesizing ammonia and methanol. The country has seven methanol plants, with a total production capacity of 7.14 Mtpa; 11 ammonia and downstream derivative plants, with a total production capacity of 5.4 Mmtpa; a urea plant, with a capacity of 0.7 Mtpa and an AUM (ammonia, urea ammonium nitrate, melamine) complex of 1.6 Mtpa. This is why Trinidad & Tobago could be considered the world's first hydrogen economy. However, hydrogen production from natural gas without CCS (grey hydrogen) is highly carbon-intensive, emitting around 10 tonnes of CO2 per tonne of hydrogen produced (Hydrogen Council // alternative sources: GH2; based on Longden et al, 2019[3]. There are also other heavy industries linked with natural gas, such as iron and steel; with a direct-reduced iron plant with a capacity of 1.6 Mtpa.

Power Generation

Power generation is virtually 100% gas-fired. Power generation installed capacity is 2.2 MW, consuming around ~250 Mmscf/d of natural gas to provide electricity for its 1.5 million inhabitants. The first utility scale renewable energy project, a solar PV farm with a total capacity of 112 MW, was given the go-ahead in late 2022 and will start the construction phase in early 2023 (source: MEEI)[4].

[3] https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf // https://gh2.org/blog/mirage-blue-hydrogen-fading#:~:text=Grey%20hydrogen%20produces%20large%20greenhouse,every%201%20kilogram%20of%20hydrogen
[4] https://www.energy.gov.tt/wp-content/uploads/2022/12/Media-Release-Signing-Ceremony-for-Utility-Scale-Solar-PV-Project.pdf.

Challenges and Opportunities
for Natural Gas

Natural Gas Supply and Regional Integration

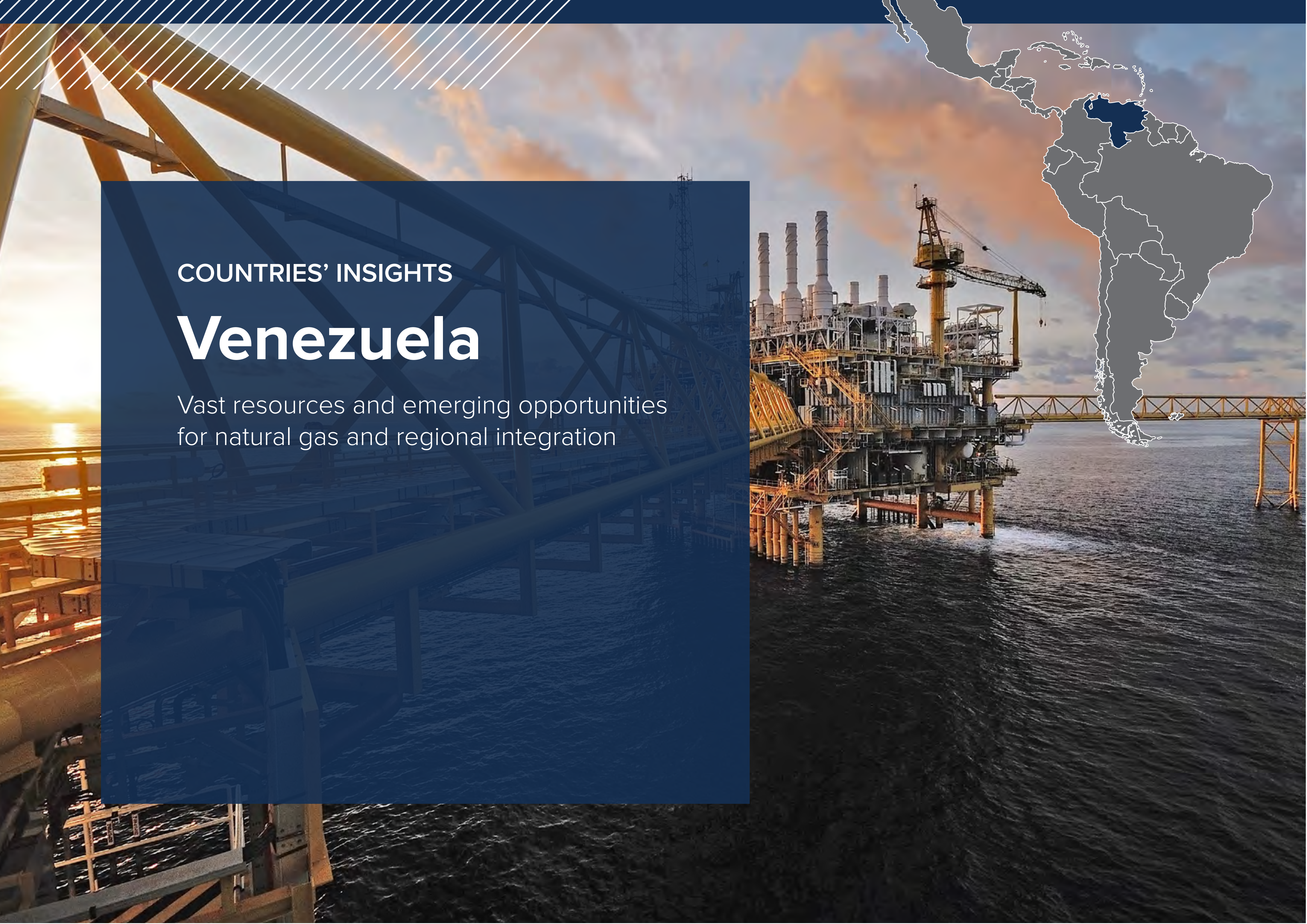
The first challenge is to continue feeding natural gas exports and chemicals production, the country's main economic activities, given a waning natural gas production. Investing in natural gas exploration is necessary to increase reserves and sustain the country's development opportunities and to continue decarbonizing other regions, and providing critical chemicals to the world. On the other hand, proximity to Venezuela's giant non-associated gas offshore fields provides excellent opportunities for regional integration, providing off-take opportunities to leverage investments in Venezuela while keeping high rates of infrastructure utilization in Trinidad & Tobago.

Source: ARPEL

Greening Methanol and Ammonia production

The second challenge is to make ammonia and methanol production greener. In that sense, in a country with a lot of experience in this industry and depleted gas fields that can serve for geological storage of CO_2, blue hydrogen (produced with fossil natural gas as a feedstock with CCS) becomes an interesting option for the country. Blue hydrogen is now cheaper to produce than green hydrogen and, considering a 90% capture rate, it generates 1-4 tonnes of CO_2 per tonne of hydrogen (source: Hydrogen Council)[5]. Green hydrogen (produced by electrolysis of water and using renewable energy) is another way to make hydrogen production cleaner; however, in small countries, procuring the land needed to deploy several GW of renewable energy could be very challenging. Trinidad & Tobago is now working on both options, and has recently launched a roadmap for developing a green hydrogen economy[6].

[5] https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf.
[6] https://publications.iadb.org/en/roadmap-green-hydrogen-economy-trinidad-and-tobago.



COUNTRIES' INSIGHTS

Venezuela

Vast resources and emerging opportunities for natural gas and regional integration

The severe economic crisis in Venezuela has exacerbated shortages of food and medicines, and UN figures suggest four million people have left the country since 2015[1]. One of the UN´s sustainable development principles is: leaving no-one behind: *"a premise for the fulfilment of the 2030 Agenda, inspires us to remain focused on the needs of the people above any political interest and to build and reach agreements towards sustainable recovery and development"*[2].

Climate

In the Venezuelan NDCs November 2021[3] update, among all the different topics that have been mentioned, the contribution of the natural gas sector is key to future activities. The first priority is flare gas recovery, generated by fugitive emissions in the hydrocarbons industry. The estimation of flaring emissions is approximately 75% of GHGs, according to official data in the abovementioned document. Moreover, flaring recovery, as highlighted by IEA[4], is a priority to solve, for both environmental commitments and from the economic perspective to maximize commodity recovery.

The second priority is related to the transport sector, where NGVs will play a key role in reducing emissions. The substitution of diesel public buses with NGVs can lead to a 40% reduction in emissions.

Reserves

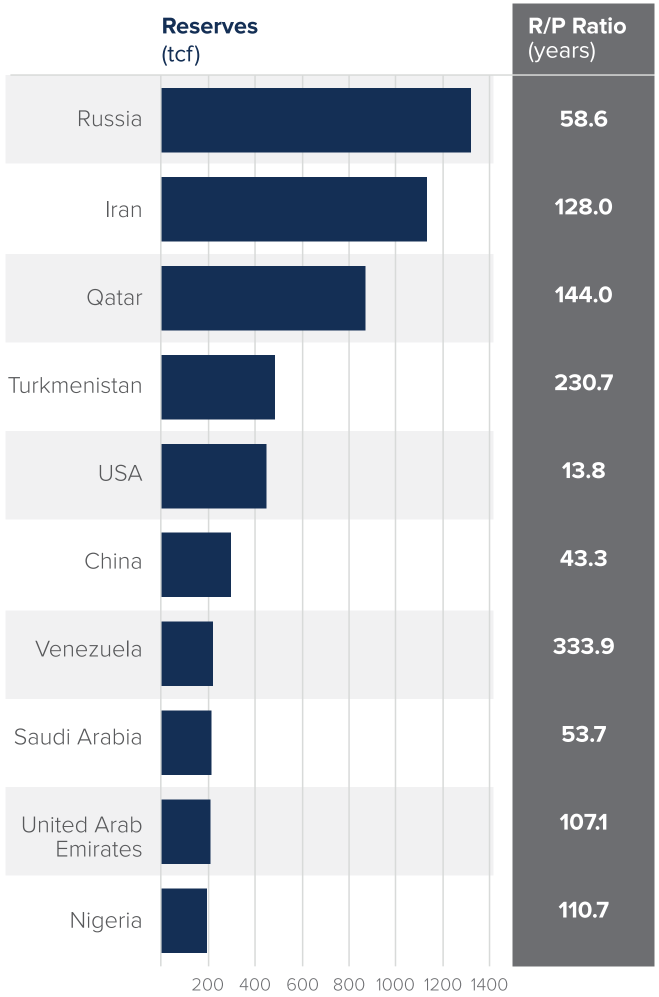
Venezuela's gas reserves place it in seventh place in volume terms globally and second in the Americas, after the USA. The country holds 79.3% of Latin America and the Caribbean's proven reserves (P1): 221 Tcf, according to the latest BP Statistical Report, 2022[5].

However, only 18% of Venezuela's proven reserves are in production (approximately 39 Tcf), representing very low development levels in comparison with the R/P ratio of the main world producers.

Of the proven reserves, around 80% are associated with oil production. The remaining 20%, 40 Tcf, of proven non-associated reserves are equivalent to the overall proven reserves of Argentina, Brazil, Trinidad & Tobago, and Mexico. Additionally, Venezuela has identified new wells offshore and onshore, with the expectation of 216 Tcf of conventional gas, mainly from offshore and non-associated reserves. This could result in a potential of 400 Tcf, with 160 Tcf of non-associated gas.

Natural Gas Reserves
Top 10 Countries

Data Source: BP Statistical Review of World Energy 2022[6]



[1] UN, 2019, Estimation 4 million people. https://news.un.org/en/story/2019/06/1040001.
IMF, 2022, estimation, 7 million people. https://www.imf.org/en/News/Articles/2022/12/06/cf-venezuelas-migrants-bring-economic-opportunity-to-latin-america.
[2] https://unsdg.un.org/un-in-action/venezuela-bolivarian-republic.
[3] "Actualización de la Contribución Nacionalmente Determinada de la República Bolivariana de Venezuela para la lucha contra el Cambio Climático y sus efectos. NDCs". November 2021.
[4] IEA, Flaring Emissions, September 2022,
[5] Other sources, Wood Mackenzie: due to current warrant framework, estimation in a range 100 Tcf.
[6] BP Statistical Review of World Energy, 2022, flat proven reserves in the last 10 years.

Venezuela's natural gas production is in the order of 4,700 mmscfd (2021 and 2022), with some 1,800 mmscfd destined for the domestic market. The remaining production is for oil extraction and operational activities. The historic maximum production was 7,926 mmscfd, in 2016, with some 2,400 mmscfd destined for the domestic market.

Since 2016, there has been a decline in total gas production, driven by the decline in oil activities, and therefore its associated gas. This decline has been caused by disinvestment in the sector in recent years, due to the political situation of the country in the international context, and not on account of declining reserves. This report will not address the political reasons that have generated the disinvestment situation; it will only focus on dealing with the current challenges and opportunities, under the new international discussion of security of supply.

Considering the current level of proven reserves, potential natural gas production in a seven-to-eight year scenario is in the range of 9,500 mmscfd and 15,000 mmscfd, depending on the sources used to calculate the production development scenarios. The assumptions for the "Strategic Plan 2016–2025", the 10,500 mmscfd scenario, seven-year horizon, could be a technically viable scenario, taking into account the current conditions of the industry, according to Venezuela´s Association of Gas Processors (AVPG), as highlighted in the document *"Planteamiento Institucional de la Asociación Venezolana de Procesadores del Gas (AVPG) para la recuperación y desarrollo de la industria del Gas Natural en Venezuela".*

Approximately 6,500 mmscfd (62%) would be associated gas and 4,000 mmscfd (38%) would be free or non-associated gas.

Venezuela's potential domestic gas uses could eliminate the consumption of fuel and diesel in power plants, reinforce its petrochemical industry, and revitalize its industrial sector, and specifically steel factories.

The country is geographically well placed to market its gas in the Atlantic basin, as well as, the Pacific, through the Panama Canal.

The potential of additional gas exports of 2,000 mmscfd could be made available to the market in the short and mid-term, through the giant offshore field Cardon IV[8] and also through Atlantic LNG (Trinidad & Tobago)[9], with gas from the Plataforma Deltana[10] in Venezuela but close enough to the Trinidad & Tobago facilities.

Venezuela
Natural Gas Reserves

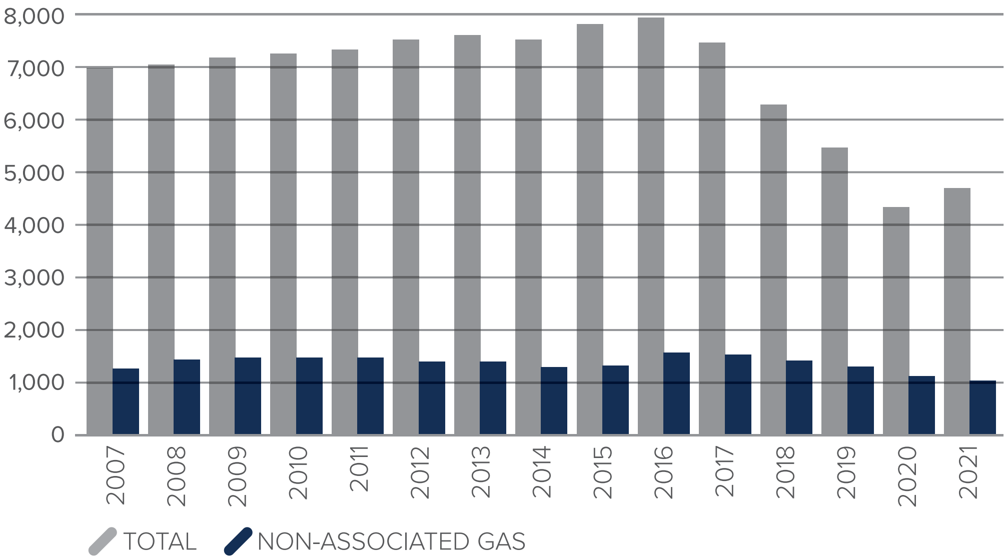
Source: PDVSA 2016, Vice-Ministry of Gas 2016-2017, AVPG estimation 2022[7]

RESERVES	TCF
1. PROVEN	221.1
2. PROBABLE	31
3. POSSIBLE	30
TOTAL RESERVES:	**282.1**
EXPECTED	
4. ONSHORE	53
5. OFFSHORE	163
TOTAL EXPECTED:	**282.1**
POTENTIAL:	**498.1**

	TCF
DEVELOPED	**39.3**
PROVEN RESERVES (19%) +120 YEARS	
PROVEN RESERVES	
ONSHORE	**86%**
OFFSHORE	**14%**
ASSOCIATED	**82%**
NON-ASSOCIATED	**18%**

Venezuela
Natural Gas Production
Million scf/d

Source: PDVSA 2010-2016, Vice-Ministry of Gas (2016-2017), OPEC Repots, AVPG



[7] AVPG. 2022 "Planteamiento Institucional de la Asociación Venezolana de Procesadores del Gas (AVPG) para la recuperación y desarrollo de la industria del Gas Natural en Venezuela"
[8] First exploration success 2009.
[9] Reuters 25.01.23. US issues license to Trinidad & Tobago to develop Venezuela offshore gas field.
[10] Some exploration activity in the early 1980s, development early 2000s.

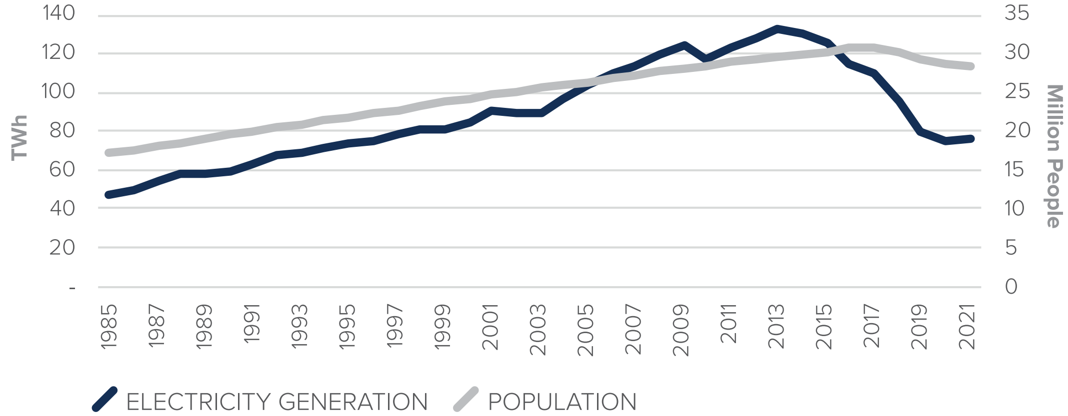
Power generation

The solution of power blackouts and electricity rationing is also a key priority for the country, which has resulted in closing workplaces and schools for days in some periods. The decline in generation is a result of technical failures affecting both the hydro and thermal generation. Electricity generation has also regressed, to the levels of the mid-1990s. However, a deeper analysis shows a ratio of electricity generation/population, similar to 1985 (2.7 TWh/million inhabitants).

A considerable number of large investments will be required to upgrade new generation transmission and distribution networks. Although Venezuela´s power system is mainly based on hydro capacity, the effects of La Niña and El Niño result in a high dependency on back-up solutions, where natural gas is the best alternative to provide stability during the intermittent periods of renewable generation.

Venezuela Electricity Generation and Population

Data Source: BP Statistical Review of World Energy 2022 and United Nations 2022



SECTION 6

Final Remarks

Energy transitions are complex processes encompassing technical, economic, and social dimensions. While the Paris Agreement clearly set the common goal of reducing GHG emissions to stabilize global warming and climate change, many pathways exist to achieve this objective. Each country begins from a different starting point regarding resource endowment, economic structure, GHG emissions profile, poverty, institutional framework, and other factors, so **there will be at least as many pathways as countries in the world.** As seen in this white paper, natural gas has a critical role to play in these decarbonization journeys.

At the same time, the world is rapidly approaching the threshold of a 1.5°C increase in temperature. Population and economic growth will continue to drive the demand for energy and GHG emissions upwards in the coming decades. Unfortunately, the technologies we would need to put the world on track to meet the threshold objective are not readily available, neither are the infrastructure or regulatory frameworks. In this scenario, **timing becomes a critical factor, as emissions must be consistently cutas quickly as possible. Natural gas, by far the cleanest of the fossil fuels, could offer effective solutions today because of the maturity of its technology and value chains. By replacing coal and diesel, for example, natural gas could unlock the potential for renewable gases and other renewables, by providing a reliable and non-interruptible energy supply.** In other words, natural gas could provide certainty in a decision environment where deep uncertainty is the norm.

The Latin America and Caribbean region is rich in natural resources, and many of its economies rely heavily on oil and gas production, which provides a significant share of GDP, exports, investments, fiscal revenues, and quality jobs. On the other hand, **more than one-third of the population still lives in poverty, while the region contributes 4.5% of global GHG emissions from energy.** This white paper highlights that **monetizing natural gas reserves can significantly contribute to socio-economic development in the region, improving lives while taking advantage of decarbonization opportunities.** The energy transition is not neutral, and natural gas should contribute to the just energy transition of Latin America and the Caribbean, leaving no-one behind.

Drivers for decarbonization are heterogeneous and vary depending on the country being considered. The white paper analyzes the opportunities in the power sector, transport, industry, fertilizers, and the interlinkages with biomethane, CCUS, and hydrogen. It also provides insights by country for further understanding of local realities and how these drivers apply in each of them from a strategic perspective.

However, as the scenario analyses in this document show, amid the deep uncertainties identified, it is notable that the future of the energy business, particularly natural gas, is expected to be more competitive. **Attracting investments to develop natural gas resources and infrastructure will become more challenging, so countries in the region should be proactive and make consistent decisions to take advantage of the current windows of opportunity.**

The white paper also analyzes the contribution of natural gas to regional and global energy security, the potential benefits and rising opportunities for regional integration, mainly between the emerging countries in the Caribbean area, and the increasing role of LNG.

Regarding the natural gas carbon footprint, it seems clear that **the natural gas industry should do its best to mitigate GHG emissions in its own value chain, mainly looking for energy and operational efficiencies and reducing flaring, venting, and boil-offs.** The industry is already engaged in several international efforts such as the Global Methane Initiative (GMI), the Climate & Clean Air Coalition Mineral Methane Initiative (CCAC MMI), the Global Gas Flaring Reduction Partnership (GGFR) and the Oil and Gas Climate Initiative (OGCI), among others. Measurability and transparency about GHG emissions and the social and environmental impacts of the industry´s operations are key to continue building a positive, evidence-based, and continuous dialogue with policymakers, the finance sector, civil society, and other stakeholders. One of the roles of organizations such as IGU, ARPEL, or OLADE is raising the bar regarding sustainability performance and being catalysts of change.

Finally, **pragmatism is critical** to achieving the desired objectives. Results matter; in that sense, **all technologies and energy sources have a role to play. This white paper highlights the role of natural gas in the energy transition of Latin America and the Caribbean from a strategic and comprehensive point of view,** considering several and often neglected aspects of this very complex issue. The objective is to contribute to the international energy dialogue, with the hope that this white paper will help stakeholders make more informed and better sustainable development decisions for the region.

Annexes

Glossary

AMMONIA
Chemical produced by both humans and in nature in approximately equal quantities each year.
It is a colorless gas with a very pungent odor also known as gaseous ammonia or anhydrous (“waterless”) ammonia. Gaseous ammonia can be compressed and under pressure (7.5 bar) it transforms into a liquid.
80% of the ammonia manufactured is used as fertilizer. One-third of this amount is applied directly to the soil in the form of pure ammonia. The remainder is used to produce other fertilizers containing ammonium compounds, usually ammonium salts. These fertilizers are used to supply nitrogen to the plants. Ammonia is also used to make synthetic fibers, plastics, and explosives.

BACKCAST APPROACH
A planning method that starts with defining a desirable future and then works backwards to identify policies and programs that will connect that specified future to the present.

BIOGAS
Mixture of methane, CO_2, and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment. The precise composition of biogas depends on the type of feedstock and the production pathway.

BIOMETHANE
Methane produced from sustainable biomass, typically by upgrading biogas. Biomethane can be produced via different production routes using a range of feedstocks, including animal manure, agricultural residues, or wood wastes. Biomethane can be used as a direct replacement for natural gas.

CAMISEA PROJECT
Camisea is the most important gas field in Peru and, for the purposes of this paper, one of the most representative in Latin America. It is located in the heart of the Amazon rainforest in the Cusco region, which is an area of high social and environmental sensitivity, and has been developed as an “offshore inland” operation. This involves operating on land as if at sea using air and river logistics instead of constructing roads. The Camisea consortium produces natural gas and condensate.

CARBON NEUTRALITY
Balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing CO_2 from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions, all worldwide greenhouse gas (GHG) emissions will have to be counterbalanced by carbon sequestration.

CO_2
Gas of natural origin, also a by-product of the combustion of fossil fuels from fossil carbon deposits, such as oil, gas, or coal, the burning of biomass, and changes in land use and other industrial processes (for example, cement production). It is the main anthropogenic GHG affecting the Earth’s radiative balance. It is the gas used as a reference to measure other GHGs, so its global warming potential is equal to 1.

CONSTANT US$
A constant dollar is an adjusted value of currency used to compare dollar values from one period to another

CONVENTIONAL GAS
Conventional gas is trapped in naturally porous reservoir formations that are capped with impermeable rock strata. When intercepted by a well, gas is able to move to the surface without the need for pumping.

CURRENT US$
In current dollars means valued in the prices of the current year. The current dollar value of a good or service is its value in terms of prices current at the time the good or service is acquired or sold.

ELECTROLYSIS
Technique that uses direct electric current to drive an otherwise non-spontaneous chemical reaction. It is commercially important as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell. The voltage that is needed for electrolysis to occur is called the decomposition potential.

ENERGY TRILEMMA
Term generally used to describe a situation where three factors need to be considered: energy security, energy equity, and environmental sustainability.

FORECAST APPROACH
A planning method that makes predictions based on past and present data.

GDP
Measures the monetary value of final goods and services — that is, those that are bought by the final user — produced in a country in a given period of time (say a quarter or a year).

GDP PER CAPITA
The sum of gross value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output, divided by mid-year population.

GINI COEFFICIENT
Also known as the Gini index or Gini ratio, is a measure of statistical dispersion intended to represent the income inequality or the wealth inequality or the consumption inequality within a nation or a social group. It was developed by statistician and sociologist Corrado Gini.

HART-TO-ABATE SECTORS
The hard-to-abate sectors include transport (light vehicles, heavy vehicles, shipping, and aviation) and energy-intensive industries that produce basic materials: cement, steel, and petrochemicals such as plastic.

HFC
Refrigerant gases whose molecules contain hydrogen, fluorine, and carbon atoms.

HYDROGEN
A versatile energy carrier, which can help to tackle various critical energy challenges. Hydrogen can be produced from almost all energy resources, though today’s use of hydrogen in oil refining and chemical production is mostly covered by hydrogen from fossil fuels, with significant associated CO_2 emissions.

INFLATION REDUCTION ACT

Legislation to help ensure the USA remains the global leader in clean energy technology, manufacturing, and innovation. The Act's US$370 billion in investments will lower energy costs for families and small businesses, accelerate private investment in clean energy solutions in every sector of the economy and every corner of the country, strengthen supply chains for everything from critical minerals to efficient electric appliances, and create good-paying jobs and new economic opportunities for workers.

JUST TRANSITION

A set of energy policies to ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no-one behind.

LEVELIZED COST OF HYDROGEN (LCOH)

Methodology used to account for all of the capital and operating costs of producing hydrogen and therefore enables different production routes to be compared on a similar basis.

LNG

Natural gas becomes a liquid at -161°C at atmospheric pressure. Liquefied natural gas (LNG) has 1/600 the volume of natural gas in its gaseous state allowing its cost-effective transport in special ships called LNG tankers. The LNG process is used to monetize remote and isolated reserves, where it is not economical to bring gas to market directly either by pipeline or by electricity generation.

METHANE

Main component of natural gas. Methane demand is currently supplied mainly by natural gas and transported by gas pipelines. Methane demand can also be supplied by biomethane and synthetic methane using the same transmission and distribution infrastructure developed for natural gas.

METHANOL

Methanol is an organic chemical and the simplest aliphatic alcohol, with the formula CH3OH. It is a light, volatile, colorless, flammable liquid with a distinctive alcoholic odor similar to that of ethanol (potable alcohol). It is mainly produced industrially by hydrogenation of carbon monoxide.
With more than 20 million tonnes produced annually, it is used as a precursor to other commodity chemicals, including formaldehyde, acetic acid, methyl tert-butyl ether, methyl benzoate, anisole, and peroxyacids, as well as a host of more specialized chemical products.

NATURAL GAS

Natural gas comprises gases occurring in underground deposits, whether liquefied or gaseous, consisting mainly of methane.

N_2O

Nitrous oxide is a colorless, volatile gas with a sweet smell, whichcauses hallucinations and a euphoric state in humans. It is used medically for its anaesthetic and pain-reducing effects.

NF_3

Nitrogen trifluoride (also known as trifluoroammonium, perfluoroammonium) is an inorganic compound of nitrogen and fluorine. It is a colorless, toxic, flammable, and odorless gas.

NOx

Usually used to include two gases-nitric oxide (NO), which is a colorless, odorless gas and nitrogen dioxide (NO2), which is a reddish-brown gas with a pungent odor. Nitric oxide reacts with oxygen or ozone in the air to form nitrogen dioxide.

PROVED RESERVES (1P)

Volumes of natural gas that analyses of geological and engineering data demonstrate to be recoverable under existing economic and operating conditions. The new technologies, additional successful exploratory wells, and increases in prices for natural gas can change previously uneconomic natural gas resources into Proved Reserves. Following the conventional definition of reserves by the Society of Petroleum Engineers (SPE), the term covers the project status sub-classes “On production”, “Approved for development”, and “Justified for development”.

PROBABLE RESERVES (2P)

Additional reserves which analysis of geoscience and engineering data indicate are less likely to be recovered than Proved Reserves but more certain to be recovered than Possible Reserves. In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual quantities recovered will equal or exceed the 2P or P1+P2 estimate.

POSSIBLE RESERVES (3P)

Additional reserves that analysis of geoscience and engineering data suggest are less likely to be recoverable than Probable Reserves. When probabilistic methods are used, there should be at least a 10% probability that the actual quantities recovered will equal or exceed the 3P or P1+P2+P3 estimate.

PFC

Family of compounds derived from a hydrocarbon in which the hydrogen atoms have been replaced by fluorine atoms.
The replacement of hydrogen atoms by fluorine atoms has a profound influence on the physical and chemical properties of these compounds, allowing uses and applications in very diverse fields such as electronics, chemistry, and medicine.

PRE-SALT

The pre-salt layer is a diachronous series of geological formations on the continental shelves of extensional basins formed after the break-up of the supercontinent Gondwana, characterized by the deposition of thick layers of evaporites, mostly salt. Some of the petroleum that was generated from sediments in the pre-salt layer has not migrated upward to the post-salt layers above due to salt domes. This is especially common off the coasts of Africa and Brazil.

PYROLYSIS

The pyrolysis process is the thermal decomposition of materials at elevated temperatures, often in an inert atmosphere. It involves a change of chemical composition. The process is used extensively in the chemical industry; for example, to produce ethylene, many forms of carbon, and other chemicals from petroleum, coal, and even wood, or to produce coke from coal. It is used also in the conversion of natural gas (primarily methane) into hydrogen and solid carbon char, recently introduced on an industrial scale.

R/P RATIO
The reserves-to-production ratio (R/P) is the remaining amount of a non-renewable resource, expressed in time. While applicable to all natural resources, the R/P is most commonly applied to fossil fuels, particularly petroleum and natural gas. The reserve portion (numerator) of the ratio is the amount of a resource known to exist in an area and to be economically recoverable (Proved Reserves). The production portion (denominator) of the ratio is the amount of resource produced in one year at the current rate.
This ratio is used by companies and government agencies in forecasting the future availability of a resource to determine project life, future income, and employment, and to determine whether more exploration must be undertaken to ensure continued supply of the resource.

REPOWEREU
In response to the hardships and global energy market disruption caused by the' Ukraine conflict, the European Commission has presented the REPowerEU Plan. It is a plan to save energy, produce more clean energy, and diversify energy supplies. It is backed by financial and legal measures to build the new energy infrastructure and system that Europe needs.

SF_6
Sulfur hexafluoride is an inorganic compound. Under normal conditions of pressure and temperature it is a colorless, odorless, non-toxic, and non-flammable gas, with the peculiarity of being five times heavier than air.

SYNTHETIC FUEL (RENEWABLE)
Different technological methods that mainly go through syngas, a mixture of hydrogen and carbon monoxide. The syngas is subsequently turned into liquid fuels via industrial gas-to-liquid processes. Synthetic fuels are fully compatible with the existing global fuel infrastructure. Renewable synthetic fuels or synthetic fuels in this document, is referred to low-hydrogen production.

SOx
The most common sulfur oxide is sulfur dioxide (SO2).
Sulfur trioxide (SO3) is an intermediate product during the manufacture of sulfuric acid (contact process). Sulfphur dioxide is a colorless gas with a penetrating, choking odor. It dissolves readily in water to form an acidic solution (sulfurous acid) and is about 2.5 times heavier than air.

SOUTHERN CONE
Uruguay, Argentina, Bolivia and Chile

SUSTAINABLE DEVELOPMENT GOALS
17 actions which are an urgent call for action by all countries — developed and developing—in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

TONNE-KM
Gross tonne-km is the product of total weight (including the weight of lading cars and locomotives) and the distance traveled by a train or truck.

UNCONVENTIONAL GAS
is formed in more complex geological formations which limit the ability of gas to migrate and therefore different methods are required to extract the gas. There are several types of unconventional gas, including shale gas and tight gas, which occur in reservoirs with very low permeability compared to conventional reservoirs. In these geological formations, horizontal drilling and hydraulic fracturing are often necessary for economic gas extraction.

VACA MUERTA
The Vaca Muerta formation, commonly known as Vaca Muerta, is a geologic formation of the late Jurassic to early Cretaceous periods, located in the Neuquén basin in northern Patagonia, Argentina. It is well known as the host rock for major deposits of shale oil and shale gas.

Abbreviations

AFOLU	Agricultural, Forestry, and Other Land Use sectors
ANEEL	National Agency of Electricity (Agencia Nacional de Energia Elétrica, Brasil)
ANH	National Hydrocarbons Agency (Agencia Nacional de Hidrocarburos, Colombia)
ANP	National Petroleum Agency (Agencia Nacional do Petroleo, Gás Natural e Biocombustíveis, Brasil)
AR6	Sixth Assessment Report
ARPEL	Regional Association of Oil, Gas, and Renewable Energy Companies in Latin America and the Caribbean
AVPG	Venezuelan Gas Processors Association (Asociación Venezolana de Procesadores de Gas, Venezuela)
BAU	Business as usual
Bcm	Billion cubic metres
BECCS	Bioenergy with capture and storage
BEVs	Battery electric vehicles
BNDES	National Bank of Social and Economical Development
boe	Barrels of oil equivalent
CAF	Development Bank of Latin America
CATF	Clean Air Task Force
CCAC MMI	Climate & Clean Air Coalition Mineral Methane Initiative
CCGT	Combined-cycle gas turbine
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization, and storage
CELAC	Community of Latin American and Caribbean States
CH4	Methane
CNE	National Energy Commission (Comisión Nacional de Energía, Chile)
CNG	Compressed natural gas
CO_2e	Carbon dioxide equivalent
COP	Conference of the Parties
DAC	Direct air capture
DACCS	Direct air capture and storage
DRI	Direct reduced iron
E&P	Exploration and production
ECLAC	Economic Commission for Latin America and the Caribbean
EDF	Environmental Defense Fund
EF	Electric arc furnaces
EIA	US Energy Information Administration
ENARGAS	National Gas Regulator Entity (Ente Nacional Regulador del Gas, Argentina)
EPA	United States Environmental Protection Agency
EPE	Energy Research Company (Empresa de Pesquisa Energetica, Brasil)
ESG	Environmental, Social, and Governance indicators
EU	European Union
FAO	Food and Africulture Organization
FSRUs	Floating storage regasification units
GDP	Gross domestic product
GECF	Gas Exporting Countries Forum
GGFR	Global Gas Flaring Reduction Partnership
GHG	Greenhouse gas
GMI	Global Methane Initiative
GMP	Global Methane Pledge
Gt	Gigatonnes
GW	Gigawatts
HFCs	Hydrofluorocarbons
IBP	Brazilian Petroleum and Gas Institute
IEA	International Energy Agency
IEF	International Energy Forum
IFC	International Finance Corporation
IGU	International Gas Union
IMF	International Monetary Fund
IMO	International Maritime Organization
iNDC	Intended National Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPIECA	Global Oil and Gas Association
IRA	Inflation Reduction Act
IRENA	International Renewable Energy Agency
ISSB	International Sustainability Standards Board
kg	Kilogram

kTEP	Thousands tonnes oil equivalent
kWh	Kilowatt-hour
LNG	Liquified natural gas
LTS	Long term climate strategies
m3	Cubic meter
MEF	Major Economies Forum
MMm3/d	Million cubic meter a day
Mt	Million tonnes
Mtpa	Million tonnes per annum
MW	Megawatt
N2O	Nitrous oxide
NDCs	National determined contributions
NF3	Nitrogen trifluoride
NGOs	Non-governmetal organizations
NGVs	Natural gas vehicles
NOx	Nitric oxide
OECD	Organisation for Economic Co-operation and Development
OGCI	Oil and Gas Climate Initiative
OGMP	Oil and Gas Methane Partnership
OLADE	Latin America Energy Organization
ONS	National Electricity System Operator (Operador Nacional do Sistema Elétrico, Brasil)
OSINERGIM	Governmental Body for the Supervision of Mining and Energy (Organismo Supervisor de la Inversión en Energía y Minería, Perú)
PDVSA	Venezuelan Oils S.A. (Petróleos de Venezuela S.A., Venezuela)
PEN	Energy Strategy (Política Energética Nacional de Chile)
PFCs	Perfluorocarbons
PM	Particulate matter
PPAs	Power Purchase Agreements
PV	Photovoltaic
R/P	Reserves/Production ratio
RMI	Rocky Mountain Institute
SASB	Sustainability Accounting Standards Board
SDGs	United Nations Sustainable Development Goals
SDS	IEA Sustainable Development Scenario
SENER	National Energy Secretariat (Secretaría de Energía, México)
SF6	Sulphur hexafluoride
SGT9	Mercosur Energy SubGroup 9
SIDS	Small Islands Developing States
SIEPAC	Central American Electrical Interconnection System
SIESUR	South Energy Integration System
SINEA	Andean Electrical Interconnection System
SOx	Sulfur oxide
Tcf	Trillion cubic feet
TCFD	Task Force on Climate-Related Financial Disclosures
tCO_2	Tonnes carbon dioxide
TPES	Total primary energy supply
TWh	Terawatt-hour
UN	United Nations
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPME	Mining Energy Planning Unit (Unidad de Planeación Energético Minera, Colombia)
US$	US dollar
USA	United States of America
VLSFO	Very low sulfur fuel oil
WCD	West Coast Demerara
WMO	World Meteorological Organization
WTO	World Trade Organization
YPFB	Bolivian National Oil Company (Yacimientos Petrolíferos Fiscales Bolivianos, Bolivia)

WHITE PAPER

Natural Gas in the Transition to Low-Carbon Economies

The Case for Latin America and the Caribbean

APRIL 2023

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