INSTITUTE OF THE AMERICAS

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RETHINKING THE ROLE OF NATURAL GAS TO ACCELERATE DECARBONIZATION IN LATIN AMERICA AND THE CARIBBEAN

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A report commissioned by CAF - Development Bank of Latin America and the Caribbean, prepared and written by energy experts and staff at the Institute of the Americas at the University of California San Diego

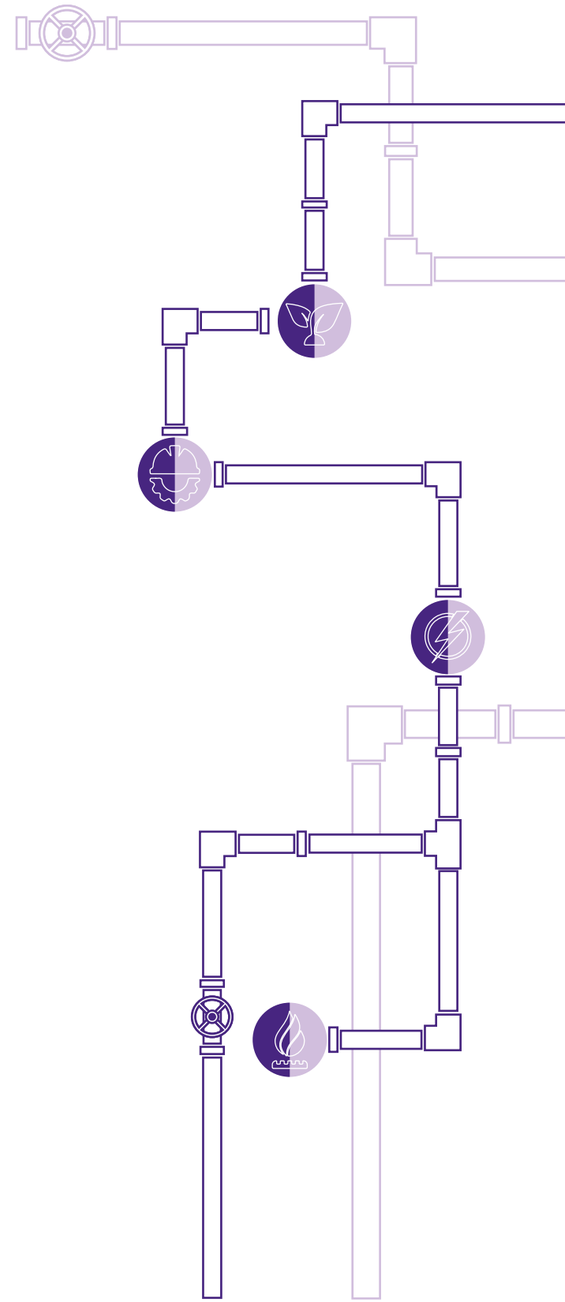
Executive Summary

It has become quite apparent that the global community must escalate the broad deployment of commercially available clean energy technologies and sources to urge decarbonization and attain Net Zero. It is also clear that such a shift will take immense effort. And as the world transitions to more widespread deployment of clean energy solutions, the challenges and concerns will also be enormous.

In Latin America and the Caribbean (LAC), for example, stranded economies and the role of national oil companies (NOCs) are of great concern. The energy transition has introduced existential questions over the future of these firms and their governments. Moreover, most, if not all, LAC markets will confront the issue of affordability. Not all countries can afford the cost and capital required for technological replacement in the near term. Workforce development must also be considered. The workforce must be prepared to accommodate the contours of the Net Zero pathway, particularly in terms of reskilling/upskilling, but also in the face of disruptors like artificial intelligence (AI). For all the talk of new technologies, there has been considerably less talk about who and what gets left behind.

But the LAC region also boasts a relatively low carbon footprint and abundant natural gas resources. These resources offer an opportunity to propel the energy transition forward and accelerate the LAC region's decarbonization while addressing some of the other concerns.

Natural gas is more immediately available to serve as a cleaner transitional fossil fuel that balances the need to decarbonize with efficient resource utilization and manageable investments. And it plays a key role for cleaner industry development across LAC nations in the short and medium term. It also allows for the decarbonization of consumption segments that cannot yet be electrified with cost-efficient technologies and can reduce the emissions intensity of the energy sector at an accelerated rate by replacing more carbon-intensive fuels and other pollutants. Methane emissions remain a great concern; natural gas policies must address this issue and the ways projects can ameliorate those emissions and, in many instances, put that methane to use. Innovative technical and commercial solutions to the problem must also be encouraged.



With development and implementation of a longer-term vision, some of the gas infrastructure can be leveraged as part of the region's future energy system. Several policy pathways point to possibilities for hydrogen and its derivatives as a new, lower carbon energy vector. In that context, and as the various stakeholders' objectives move into alignment, stranded assets may become less of a concern; they may instead be repurposed and converted to facilitate the transition to hydrogen. In the longer term, as price parity emerges, hydrogen and its derivatives will also provide an opportunity for LAC countries to become leading global suppliers of lower carbon energy sources.

This paper explores the role of natural gas in accelerating the region's transition to a Net Zero economy, with a focus on key National Oil Companies (NOCs) and their pivotal role in driving decarbonization efforts. As some of Latin America's most powerful organizations **—inside and outside of the energy sector—** NOCs have the resources, political connections, and the obligation to make changes.

There is a rather clear delineation between most of the region's NOCs in terms of where they stand on the path toward Net Zero. The NOCs can generally be grouped as follows:

- Early Adopters Seizing the Moment
- Developing a Strategy to Seize the Moment
- Incomplete at the Moment

This paper examines and considers the global and regional context for the energy sector, key lessons from past projects, as well as the role for NOCs and concludes with four overarching, pragmatic policy recommendations that can serve as a blueprint for navigating the complex challenges and opportunities inherent in the LAC region's transition toward a more sustainable energy future and accelerated decarbonization:

- Address Untargeted Fossil Fuel Subsidies
- Create a Free Market for Natural Gas and LNG
- Urge NOCs to Adopt Net Zero Targets with Timelines and Strategies
- Decarbonize through Natural Gas and Short-Term Decarbonization Goals

By embracing these recommendations, policymakers, industry stakeholders, and other relevant actors can collectively pave the way for a greener, more prosperous future for Latin America and the Caribbean.

List of Acronyms

AI - Artificial Intelligence
ALUR - Alcoholes del Uruguay (ANCAP Group)
ANCAP - Administración Nacional de Combustibles, Alcoholes y Portland (Uruguay)
APS - Announced pledges scenario, reference to IEA's "Energy Outlook" report
AR - Augmented reality
B+, BB - standard U.S. credit ratings
BAU - Business-as-usual scenario
CADE - Conselho Administrativo de Defesa Econômica (Brazil)
CBAM - Carbon border adjustment mechanism (CBAM)
CCAC - Climate and clean air coalition
CCS - Carbon capture and storage/sequestration
CCUS - Carbon capture, utilization, and storage
CEDIB - The Bolivian Center for Documentation and Research
CEO – Chief executive officer
CFE - Comisión Federal de Electricidad (Mexico)
CMGN - Committee to Monitor the Unbundling of Natural Gas market (Comitê de Monitoramento da Abertura do Mercado de Gás Natural)
CONICET - Consejo Nacional de Investigación en Ciencia y Tecnología – National Scientific and Technical Research Council, government agency
COP 26 and 28 - Conference of the parties
CSIS – Center for Strategic and International Studies
CSR - Corporate social responsibility
E&P - Exploration and production
EDF - Électricité de France
ENAP - Empresa Nacional del Petróleo (Chile)
ENGIE - French multinational utility company
EOR – Enhanced oil recovery
EPA – Environmental Protection Agency (U.S. Government)
ESG – Environmental, social, governance
EU - European Union
EV - Electric vehicle
FID – Final investment decision
G20 - Group of 20, intergovernmental forum
GHG - Greenhouse gas
GNL Quintero - LNG terminal (Chile)
GSA – Natural gas supply agreement
GWP - Global warming potential
H2U - ANCAP program
HIF – Global eFuels company "Highly Innovative Fuels"
HVO - Hydrotreated vegetable oil
IDB - Inter-American Development Bank
IDR - Issuer default ratings (credit)
IEA - International Energy Agency
IMEO - International Methane Emissions Observatory
IOA - Institute of the Americas
LAC - Latin America and the Caribbean
LAICS - Latin American industry classification system
LDAR – Leak detection and repair
LENG - Low-emission natural gas
LNG - Liquefied natural gas
MIEM - Ministry of Industry, Energy, and Mining (Uruguay)
MOU - Memorandum of understanding
NAICS - North American industry classification system
NBS - Nature-based solutions
NDC - Nationally determined contribution
NGC - Natural Gas Company of Trinidad and Tobago Limited
NGV – Natural gas vehicles
NOC - National oil companies
NPR - National Public Radio (U.S.)
NZE - Net Zero Emission Scenario, reference to IEA's "Energy Outlook" Report
OEMLAC - LAC Methane Emissions Observatory
OGMP - The Oil & Gas Methane Partnership
OLADE - La Organización Latinoamericana de Energía
OPEC - The Organization of the Petroleum Exporting Countries
PDVSA - Petróleos de Venezuela, S.A.
PEM - Proton exchange membrane
PEMEX - Petróleos Mexicanos (Mexico)
R&D - Research and Development
RE - Renewable energy
RELAC initiative – Renewable Energy in Latin America and the Caribbean
RWE - German multinational energy company
SAF - Sustainable aviation fuel
SDG - Sustainable development goals
SEC - Securities and Exchange Commission
SLO - Social license to operate
SOE – State-owned enterprise
SRI - Sustainable and responsible investing
STEPS - Stated Policies Scenario, reference to IEA's "Energy Outlook" report
TBG - Transportadora Brasileira Gasoducto Bolivia-Brasil
TESG - Technology, Environmental, Social and Governance
TGP - Transportadora de Gas del Peru

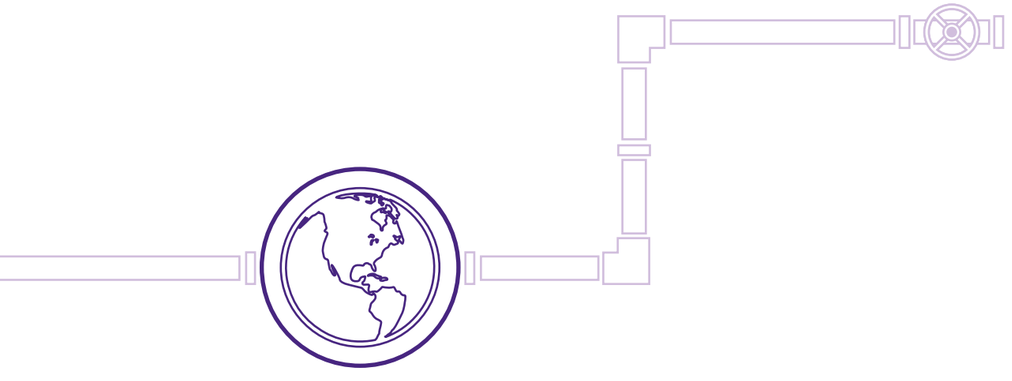
THyGA - Testing Hydrogen Admixtures for Gas Appliances
TVET - Technical and Vocational Education and Training
UNEP – United Nations Environmental Programme
UNFCCC - United Nations Framework Convention on Climate Change
UTE - Administración Nacional de Usinas y Transmisiones Eléctricas (Uruguay)
VR - Virtual Reality
YPF - Yacimientos Petrolíferos Fiscales, S. A. (Argentina)
YPFB - Yacimientos Petrolíferos Fiscales Bolivianos (Bolivian NOC)
Y-TEC – YPF (Argentina) Technology company

Measures and Compounds

BPD - Barrels per day
BTU —British thermal unit(s)
CO2 - Carbon Dioxide
GW – Gigawatt (electricity)
H2 - Hydrogen
kg - Kilogram
km - Kilometer
MCF – One thousand cubic feet (volume of gas)
MCM – One thousand cubic meters (volume of gas)
MMBtu —1,000,000 British thermal units
Mtpa – Million tons per annum
MW - Megawatts (electricity)

"The term "Latin America and the Caribbean" encompasses the geographic region of the American continent that is made up of more than 40 countries and territories running from Mexico to Cape Horn. The area can be divided into four sub-regions: South America, Central America, the Caribbean, and Mexico. For the purposes of this document, including the analysis of energy sector statistical data, this paper considers only the 27 Latin American Energy Organization (OLADE) member countries and the sub-regions that international organization uses to define the area when referring to Latin America and the Caribbean (LAC)."

Editor's Note



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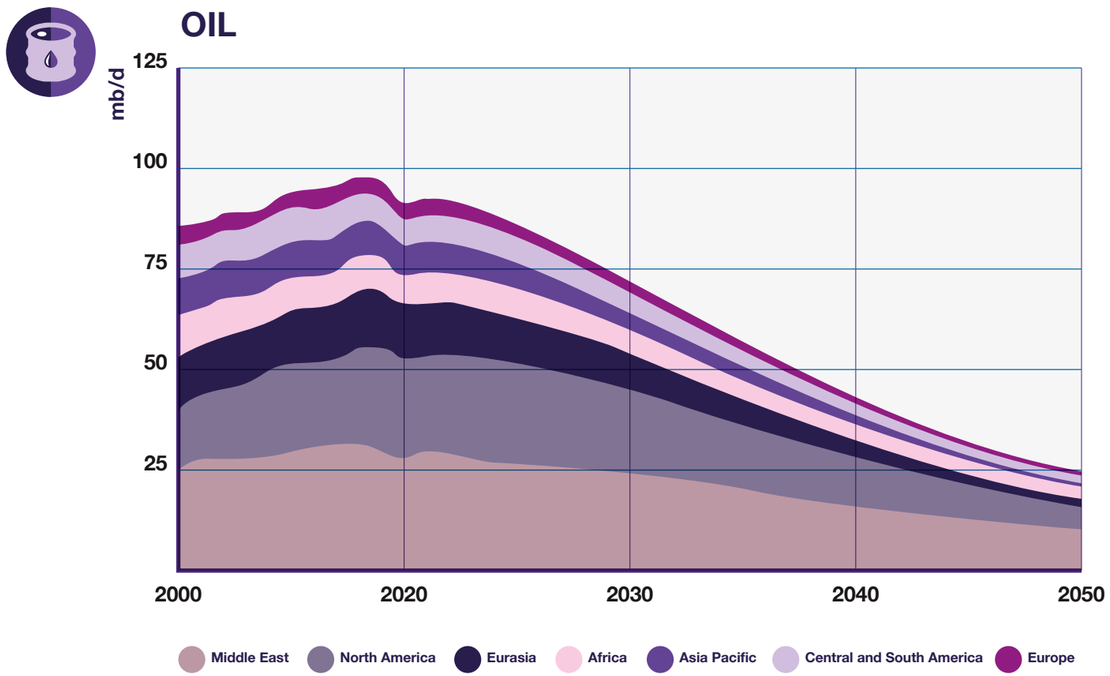
The Context

In 2021, the International Energy Agency (IEA) released Net Zero by 2050 – A Roadmap for the Global Energy Sector (IEA, 2021). It was a monumental report, and a call to action. The publication triggered extensive discussion, as it underscores the enormous scale of effort it will take to accomplish Net Zero. The report also highlights the need to rapidly ramp up renewables. Countries will have to escalate the broad deployment of commercially available clean energy technologies and sources to urge decarbonization forward. But even under the most aggressive scenarios, fossil fuels will have a role for some time to come, though their production will decline. By 2050, global oil production will stand at 25 million barrels/day.

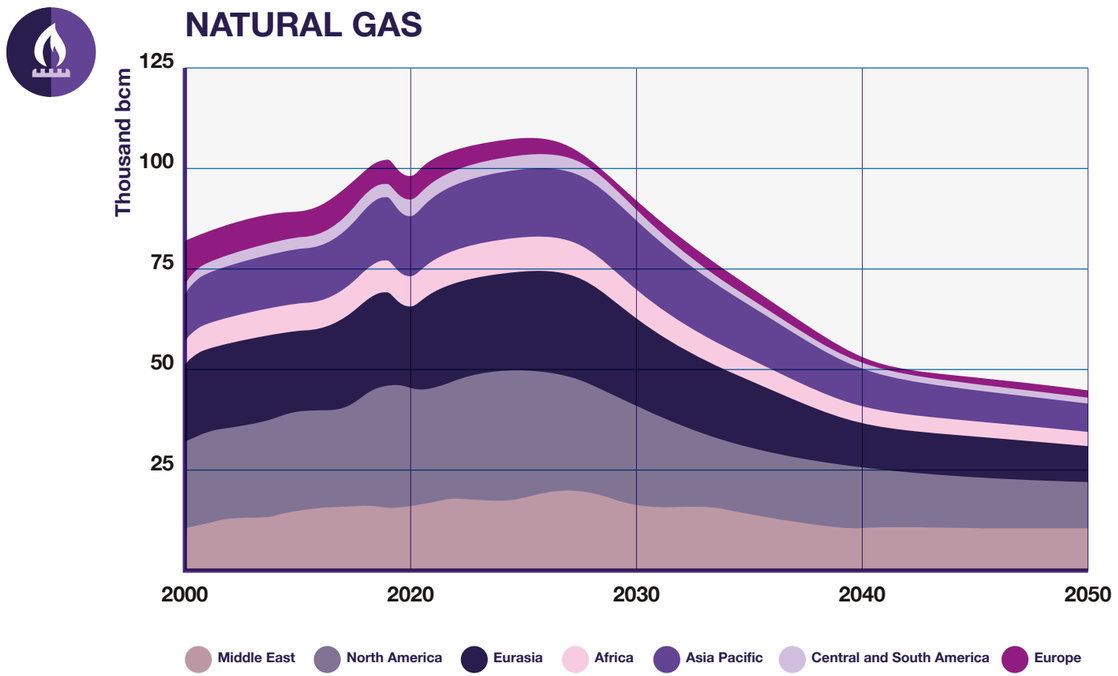
Historic & Projected Global Oil and Natural Gas Production, 2010-2050



Source: IEA • Figure 1

Latin America and the Caribbean (LAC) possesses significant hydrocarbons reserves, particularly in countries like Brazil, Guyana, Venezuela, Mexico, and Argentina. The International Energy Agency (IEA) states that the region produced more than eight million barrels of oil per day (mmbbl/d) in 2022—**just under 10% of global production**— and approximately 185 billion cubic meters (bcm) of natural gas, or just **under 5% of global supply**, that same year. The IEA Latin America Energy Outlook notes that Argentina is the region's primary natural gas producer, accounting for **nearly 25% of supply**, with Brazil, Mexico and Trinidad & Tobago each with **around 15% of supply**. Bolivia, Venezuela, and Peru each produce **between 5-10%.**[1]

These natural gas resources offer an opportunity to propel the energy transition forward. Their use should be strategically expanded to facilitate a systematic shift from more environmentally harmful sources to quickly impact emissions levels.



Source: IEA • Figure 1a

[1]International Energy Agency, Latin America Energy Outlook 2023, November 2023. https://iea.blob.core.windows.net/assets/1055131a-8dc4-488b-9e9e-7eb4f72bf7ad/LatinAmericaEnergyOutlook.pdf

The Power of Natural Gas

Unlike other approaches, such as the electrification of transportation, the expanded use of natural gas can ensure a swift, effective response to climate concerns over the short-to-medium term. This proactive approach can not only strengthen regional competitiveness, it can also position LAC countries as significant global suppliers of low-carbon energy sources. Some other key factors include:

- **Natural gas serves as a valuable medium-term solution** for areas that are not yet easily electrifiable, thus making a positive contribution to energy security and overall system resilience.

- **Natural gas in LAC countries** actively facilitates source replacement, enhancing energy efficiency in thermal applications and superseding more carbon-intensive sources in economies' hard-to-electrify segments.

- Prospective studies indicate that, even in carbon-neutral scenarios, fossil fuels will probably continue to represent around **43% of LAC countries' energy supply mix by 2050 (22% oil products, 19% natural gas, 2% coal) (OLADE, 2021).** To achieve carbon neutrality, countries must focus on reducing the carbon intensity of the fuels that will continue to shape the energy landscape.

Overall, natural gas can provide the most immediate help in improving transformation and process efficiency in the thermal end use of energy. It reduces specific emissions vis à vis industrial level use of liquid fuels and coal; it allows for the decarbonization of consumption segments that cannot yet be electrified with cost-efficient technologies; and it can speed the reduction of the energy sector's emissions intensity by replacing more carbon-intensive fuels and other pollutants. As long as natural gas continues to be produced, it can be leveraged to speed decarbonization.

For its part, the LAC region and its energy sectors are well on their way down the transition path. The region's electricity generation is more renewables-reliant and less emissions-intensive than that of the rest of the world. In 2022, 65% of LAC electricity generation was renewables based; coal was used far less than natural gas and biomass for such purposes. But challenges remain, most notably because transportation represents around 40% of the region's final energy consumption; industrial consumption comes in at around 28%, and the use of low efficiency liquid fuels to generate electricity persists (OLADE, 2021).

Transitioning away from liquid fuels will be key to reducing LAC region emissions. Indeed, such a transition would be more immediately effective than alternatives like transport electrification, according to current timelines. Domestic distribution barriers will have to be eliminated and regional integration achieved to foster the most optimal gasification of the power and industrial segments to reach that end.

As such, the region's natural gas network must be optimized over the near and medium-term as part of the transition. Managing methane emissions through reducing leaks (i.e., through advanced leak detection and repair—LDAR—systems), venting, and flaring will be key to enhancing efficiency as near and medium-term consumption increases. These activities will demand immediate investment and increased legal and regulatory efforts. COP28 participants agreed on these issues, and UN and OLADE efforts to measure and manage methane reduction reflect this awareness. All these efforts will help ensure that the region remains on track for 2050 Net Zero commitments. They will alter power sector emissions and hard-to-abate industrial segments while also creating capacity for global low carbon natural gas exports in the form of liquefied natural gas (LNG).

But not all fossil fuel consumption can be electrified, nor is all energy electricity. Further, many countries cannot afford the cost and capital required for technological replacement in the near term. Affordability is crucial. The transition will not be linear for economies' hard-to-abate segments, like cement and steelmaking, among other industrial processes.

The use of hydrogen, particularly hydrogen derivatives, could be key to decarbonizing some of those segments. But as of this writing, the hydrogen outlook is still heavily debated—largely due to cost. Economic and commercial viability issues must be solved before LAC countries can consider a more robust market and role for hydrogen and derivatives. Today, green hydrogen production costs US$ 4.5-12 /kg (Bloomberg, 2023); the Uruguay 2030 green hydrogen roadmap targets production in the US$ 1.2-.4 /kg range, which is consistent with today's cost of diesel fuel (MIEM, 2022). **IEA estimates show that only 7% of the world's green hydrogen development projects will be operational by 2030.** And it will likely cost three to four times more to use green hydrogen than grey hydrogen for fertilizer, based on 2023 prices. Current synthetic fuel production from demonstration projects is not yet cost competitive, either.

The Policy Piece

The European Commission's proposed directive for common rules for internal markets in renewables and natural gases and hydrogen (COM (2021) 803) may provide an important reference as well as a marker for policy evolution that could impact LAC exporters to Europe. The directive seeks to create a unified framework for reducing carbon emissions in gas markets by establishing consistent regulations for natural gas and hydrogen transmission, distribution, supply, and storage.[2] The directive includes plans to develop a European hydrogen market, encourage competition, provide dedicated infrastructure, establish a network of hydrogen operators, and facilitate trade with non-EU countries. Key elements of the directive focus on promoting consumer choice and competition, ensuring market access and fairness, and supporting the transition to renewable and low-carbon gases.[3]

Once the directive is officially adopted, EU member states will have two years to convert its provisions into national law.

> The directive is part of the "Fit for 55" package, which seeks to align EU laws with climate goals to reduce emissions by 55% by 2030 and achieve climate neutrality by 2050.[4]

The EU also published regulations that establish a carbon border adjustment mechanism (CBAM) in the Official Journal of the European Union, on May 16, 2023. The regulations aim to address greenhouse gas (GHG) emissions associated with certain goods to prevent the risk of carbon leakage. The CBAM also seeks to halt unfair competition from third-country producers, as it compels them to pay for their pollution at the EU border. It will oblige producers of carbon-intensive products to pay an equivalent CO2 price in their own region, or fully decarbonize.[5] The effort should reduce global carbon emissions and support Paris Agreement goals, as well as incentivize third country operators to reduce emissions.[6]

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2021%3A804%3AFIN&qid=1640001545187
[3] Ibid
[4] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal/fit-55-delivering-proposals_en
[5] https://eur-lex.europa.eu/eli/reg/2023/956/oj
[6] Ibid

The Challenges Ahead

Stranded economies and the role of national oil companies (NOCs) are of great concern as the world transitions to cleaner energy. The energy transition has introduced existential questions over the future of these firms and their governments. Latin America and the Caribbean (LAC) have several well-run NOCs **—an advantage for the transition—** but there will still be political challenges. Several economies depend on fossil fuel resource cash flows. Officials must consider this dependence and determine how to manage the transition's legacy issues.

And for all the talk of new technologies, there is considerably less talk about who and what gets left behind. Many worry that the remaining oil and gas (O&G) infrastructure, much of which must be refurbished, may go uncared for. But if a longer-term vision is developed and implemented, some of this infrastructure can be leveraged as part of the region's future energy system. Several policy pathways point to possibilities for hydrogen and its derivatives as a new, lower carbon energy vector—a win-win for many. In that context, and as the various stakeholders' objectives move into alignment, stranded assets may become less of a concern; they may instead be repurposed and converted to facilitate the transition to hydrogen. In the longer term, as price parity emerges, hydrogen and its derivatives will also provide an opportunity for LAC countries to become leading global suppliers of lower carbon energy sources.

Workforce development must also be considered. The workforce must be readied to accommodate the contours of the Net Zero pathway, particularly in terms of reskilling/upskilling but also in the face of disruptors like artificial intelligence (AI). Moreover, most, if not all, LAC markets will confront the issue of affordability.

As stakeholders grapple with these concerns, and build solutions, opportunities for economic growth and development emerge. The call to action stands to benefit many LAC countries and the markets they serve.

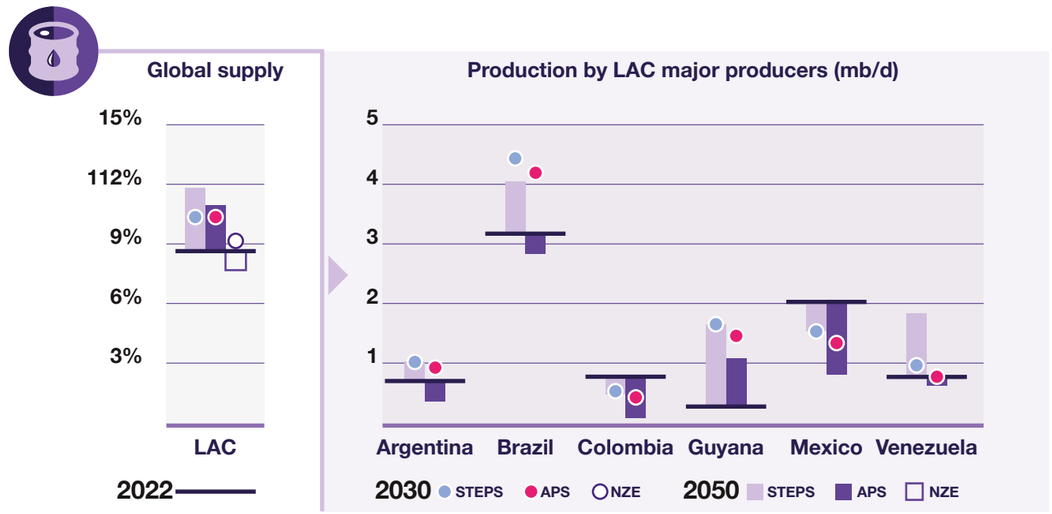
Research Questions and Issues

- How can natural gas be leveraged for economic and energy security, and in many legacy infrastructure cases, be repurposed during and after the energy transition to ensure a Net Zero economy?
- How can LAC countries leverage existing interconnections to boost the energy transition?
- How can LAC nations be the global supplier of choice for low-carbon energy in the coming years?
- What are the LAC region's fundamentals and key competitive advantages?

Latin America and the Caribbean Oil & Gas Sector: A Status Check

The IEA's Latin America Energy Outlook 2023 noted that LAC nations' oil production outlook varies from producer to producer. The report presents several scenarios to understand the region's hydrocarbons potential and outlook. In their Stated Policies Scenario (STEPS), which is based on a detailed review of the current policy landscape, the outlook notes that "overall oil output in LAC rises to 2030 and then increases further through to 2050." In the IEA Announced Pledges Scenario (APS), which intends to illustrate the extent to which announced ambitions and targets can deliver the emissions reductions needed to achieve Net Zero by 2050, the outlook notes that oil output "declines after 2030 as domestic and global oil demand contracts." In the IEA Net Zero Emissions (NZE) scenario, which sets forth a normative scenario that shows a pathway for the global energy sector to achieve Net Zero by 2050, the outlook notes that "oil supply starts to decline before 2030 and the region mostly maintains its share of global production up to 2050"[7] (Figure 2).

LAC Oil Production and Supply Under IEA Scenarios, 2030, 2050



Most major LAC oil producers increase output to 2050 in the steps, while production declines in the APS in all countries except Guyana.

Source: IEA • Figure 2

[7]Ibid

The LAC region's offshore basins, like Brazil's pre-salt fields and Guyana's rapidly developing Straboek block, hold considerable promise for exploration and production (E&P) activities. The development of unconventional resources, particularly in Argentina's Vaca Muerta, provides a pathway to LNG project expansion.

LAC E&P activities are concentrated in the above-mentioned areas as well as in Venezuela's Orinoco Oil Belt, Gulf of Mexico deepwater, and Argentina's unconventional shale plays. Offshore E&P activities, particularly in deepwater and ultra-deepwater fields, represent a significant portion of LAC nations' upstream sector. Guyana, Brazil, and, increasingly, Suriname have emerged as major players in offshore oil production.[8]

But certain issues will continue to impact how much of the region's resource potential can be fully developed and leveraged. Macroeconomic challenges in some parts of the hemisphere remain. And the ability to continue to attract investment, with a focus on technological advancements to enhance efficiency and reduce costs in the face of various challenges, is also an issue.

Investment in the LAC region's upstream O&G projects has fluctuated in recent years due to a variety of issues, including commodity price volatility, regulatory uncertainty, and geopolitical risk. The upstream O&G regulatory environment, in particular, varies greatly across the area. Some governments have implemented reforms to attract investment and promote development. Others have not. Regulatory uncertainty and changes in fiscal policies can impact investment decisions and project economics.[9]

Environmental and social elements have also become increasingly important in shaping the region's upstream O&G outlook. Interest in environmental issues, carbon emissions, and sustainable practices has become commonplace. Environmental, social, and governance (ESG) concerns, particularly when it comes to private investment in the sector, as well as social license to operate, play critical roles in this arena.

Environmental, Social, and Governance Framework

The ESG framework has emerged as an organizing principle in the ever-evolving landscape of corporate environmental and social responsibility. The framework allows a company's performance to be assessed across three key pillars: environmental stewardship, social responsibility, and governance practices.

Environmental criteria delve into how effectively a company acts as a custodian of nature, evaluating its efforts to minimize and remediate environmental impact and promote sustainability. Social criteria scrutinize the company's relationships with its employees, suppliers, customers, and the communities in which it operates, assessing its commitment to diversity, inclusion, and community engagement. Governance considerations focus on the company's leadership structure, transparency, and accountability, ensuring ethical conduct and sound decision-making processes. ESG investing has emerged as a prominent approach, encompassing sustainable investing, socially responsible investing, and mission-related investing. This approach has become standard practice for top-tier institutional investors, public investors, financial institutions, private lenders, and other stakeholders seeking to align their investment decisions with their values and long-term sustainability goals.

ESG can sometimes be confused with corporate social responsibility (CSR). CSR initiatives can be part of a company's broader ESG strategy, but ESG and CSR should be considered complementary tools—they are not interchangeable. ESG and CSR both contribute to achieving the broader objective of sustainable and responsible investing (SRI), which seeks to generate positive social and environmental impacts alongside financial returns.

In essence, ESG provides a holistic framework for companies to assess and enhance their environmental, social, and governance performance, driving positive change and fostering sustainable business practices. As companies increasingly recognize the importance of ESG considerations in their operations, the adoption of this framework will continue to grow, shaping the future of corporate responsibility and investment practices worldwide.

[8]Sproule Latin America & Caribbean Energy Outlook 2022-2023 https://sproule.com/wp-content/uploads/2023/03/Latin-America-and-Caribbean-Energy-Outlook-Report.pdf accessed on February 29, 2024.
[9]Ibid

Social License to Operate

Social license to operate (SLO) can often be confused with ESG and CSR. But CSR and ESG are actually instruments that can foster SLO. Local energy governance focuses on nearby communities and government roles within the wider national, regional, and global energy governance framework. Community actors and local governments (sub-sovereign) can contribute significantly to creating support for change and catalyze that support into action (e.g., climate action, renewable energy deployment, proper natural resource management and access).

But many questions remain, as does the lack of understanding about the ways in which community organizations and local governments can best work together. As such, it has become important to develop a way to understand stakeholder engagement. This is where a SLO comes into play.

Balza, Diaz, Gomez Parra, and Manzano, researchers at the Inter-American Development Bank (IDB), define SLO as an implicit endorsement citizens grant to extractive projects, indicating social approval. They further explain that a SLO is the result of a process whereby natural resource projects seek and obtain approval from various stakeholders. In their study, the authors identify governance as the primary predictor of trust among host communities, governments, and companies. However, procedural justice, distributive justice, and nationalism also significantly influence individuals' attitudes.[10]

Harvard professor and author, Meghan O'Sullivan, cautions against advocating for the wholesale removal of regulation and oversight in her book, Windfall. She emphasizes the importance of maintaining a SLO and describes it as the trust and confidence bestowed upon companies by the communities in which they operate; it is not formal law or regulation. O'Sullivan cites examples where shale development and fracking efforts have encountered challenges due to concerns about their impact on communities and the environment.[11] Indeed, the debate in the U.S. (and elsewhere) over fracking underscores the crucial aspect of transparency, as well as community and stakeholder engagement from early on. Many of the flashpoints that emerged could have been reduced or certainly better mitigated if a more robust approach and understanding of the principles of obtaining a SLO had been embraced.

Balza, Diaz, Gomez Parra, and Manzano's research focuses on public sentiment toward the extractive industries as a whole. They argue that understanding public sentiment is crucial because it shapes societal priorities, influences political discourse, and fuels social mobilization. Obtaining a SLO can reflect expected and observed direct impacts on communities and individual wealth.[12]

For host communities, development projects may bring positive outcomes like employment opportunities, human capital development, and increased investment in infrastructure. But the extractive industry's direct impacts are not always positive, and production externalities can harm individual wealth.

The authors highlight the importance of institutional characteristics, which they refer to as governance capacity, in the extractive industry. Governments play a critical role in granting licenses, enforcing social and environmental regulations, and managing project royalties. Strong rule of law, government enforcement capacity, and effective monitoring and accountability mechanisms incentivize companies to adhere to consensus agreements with stakeholders.[13]

Ultimately, communities prefer to be involved in the decision-making process and to receive benefits in return for allowing companies to extract resources from their lands. Balza, Diaz, Gomez Parra, and Manzano's research underscores the significance of governance, procedural justice, and community engagement in shaping attitudes toward extractive projects and ensuring sustainable development outcomes.[14]

[10]The Unwritten License: The Social License to Operate in Latin America's Extractive Sector, Balza, Diaz, Gomez Parra, and Manzano, December 2021, Inter-American Development Bank (IDB). https://publications.iadb.org/en/publications/english/viewer/The-Unwritten-License-The-Social-License-to-Operate-in-Latin-Americas-Extractive-Sector.pdf
[11]Windfall, How the New Energy Abundance Upends Global Politics and Strengthens America's Power By Meghan L. O'Sullivan, Simon & Schuster, September 2018.
[12]The Unwritten License: The Social License to Operate in Latin America's Extractive Sector, Balza, Diaz, Gomez Parra, and Manzano, December 2021, Inter-American Development Bank (IDB). https://publications.iadb.org/en/publications/english/viewer/The-Unwritten-License-The-Social-License-to-Operate-in-Latin-Americas-Extractive-Sector.pdf
[13]Ibid
[14]Ibid

Key Initiatives for Methane Venting and Flaring Control in LAC Nations

According to An Eye on Methane, an International Methane Emissions Observatory report (UNEP, 2022), methane emissions, the second most significant contributor to global warming, have surged more rapidly in recent years than they have since the 1980s. Despite methane's short atmospheric lifespan, it has a substantial impact on global warming. The Intergovernmental Panel on Climate Change (IPCC) has indicated methane has an 84-87 global warming potential (GWP) when considering its impact over a 20-year timeframe (GWP20). That number grows to between 28 and 36 when considering its impact over a 100-year timeframe (GWP100). This means that the impact of one metric ton of methane can be considered equivalent to that of 28 to 36 metric tons of CO2 over 100 years (IEA, 2021). The April 2022 IPCC assessment asserts that the world must slash methane emissions by approximately one-third to limit the average temperature rise to 1.5°C. The International Methane Emissions Observatory Report (UNEP, 2022) emphasizes that a substantial reduction in these GHG emissions would be one of the most impactful short-term measures to address climate change and move toward a Net Zero emissions world.

Meanwhile, the IEA contends that energy sector methane emissions run roughly 70% higher than official data indicate. The IEA uses its Methane Emissions Tracker (IEA, 2022), which leverages scientific studies and measurement campaigns, to estimate emissions. The organization concludes that the sector's increasingly available emissions data can be contrasted with satellite information to show that nearly all national inventories have systematically underestimated emissions. Reported emissions from producing basins, fields, and individual facilities also frequently fall short of observed levels once systematic monitoring and measurement systems are implemented.

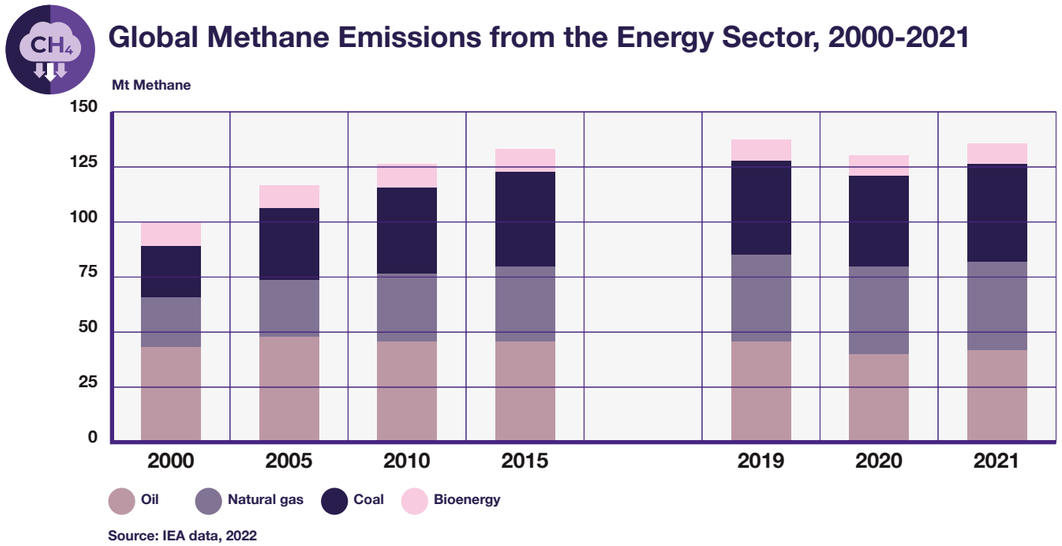
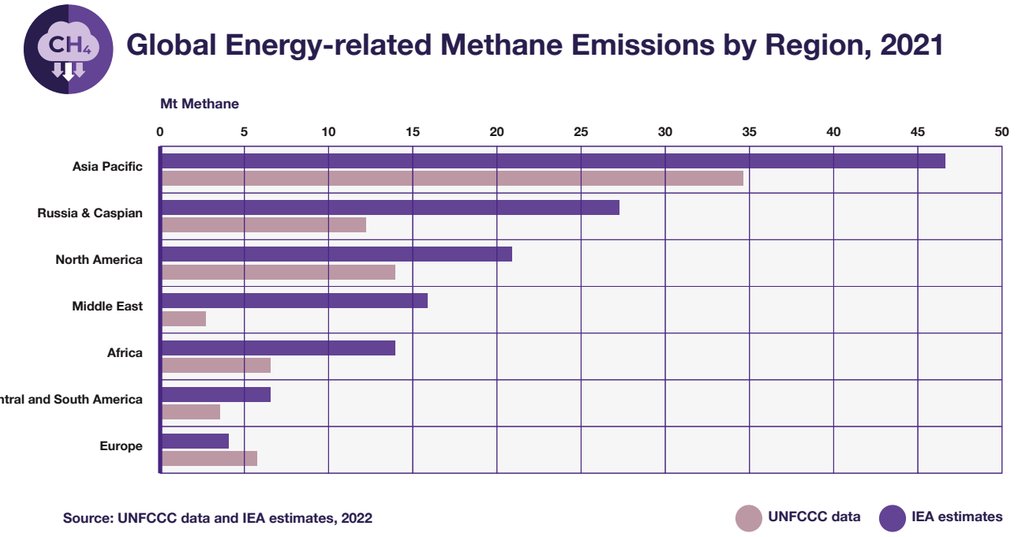


Figure 3



Source: UNFCCC data (dark blue bars) and IEA estimates (light blue bars), 2022 • Figure 4

> In 2021, the IEA estimated that LAC countries emitted 6.5 million tons of methane—significantly more than the United Nations Framework Convention on Climate Change (UNFCCC)-reported 3.5 million tons.

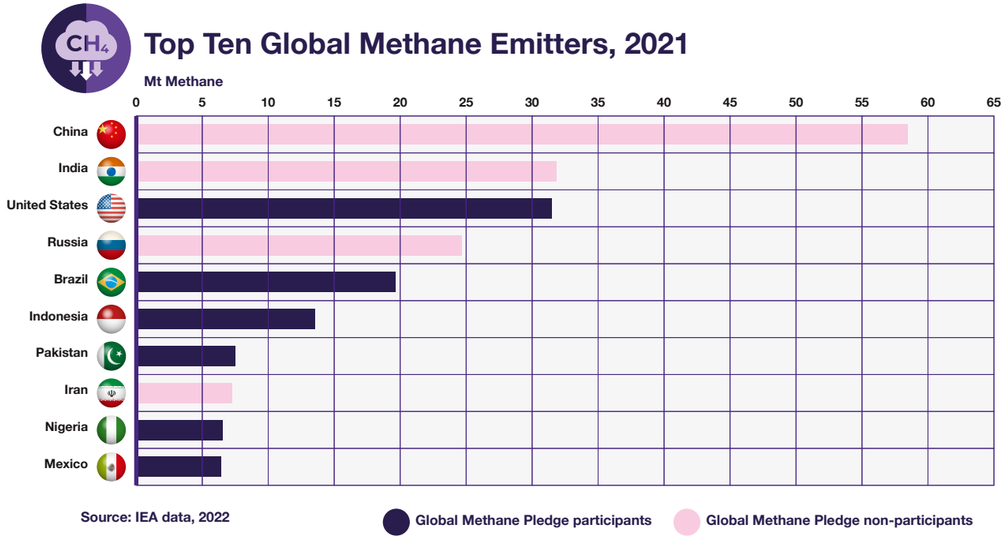


Figure 5

IEA data from 2021 also indicate that Brazil has accumulated 19.6 million tons of methane, Mexico 6.3 (IEA, 2022). This data encompasses overall methane emissions, including those from the energy sector, agriculture, and land use change.

An Eye on Methane (UNEP, 2022) underscores key considerations for climate action aimed at mitigating methane emissions, as follows:

- Methane contributes to at least one quarter of current global warming
- The O&G sector has the potential to reduce methane emissions by 75% by 2030
- The International Methane Emissions Observatory serves as the UN mechanism for establishing reporting standards and transparency in information
- The development of more specific actions requires more accurate data

The Methane Pledge Initiative

In November 2021, the United States and the European Union jointly initiated the Methane Pledge during the 26th United Nations Conference of the Parties on Climate Change (COP26). **Over 150 countries, including 30 LAC nations, pledged to collaboratively decrease global methane emissions by at least 30% below 2020 levels across all sources, not just energy, by the year 2030.** While the Methane Pledge is deemed a critical step, some major global emitters have yet to join this accord.

LAC countries generally demonstrated their dedication to methane reduction by endorsing the Global Methane Pledge, but some of the region's O&G-producing countries, like Bolivia, Guatemala, and Venezuela, chose not to participate. Participants in this pledge voluntarily work to contribute to the worldwide initiative.

The IEA indicates that a 30% drop in global methane emissions over the next decade would have the same impact on global warming by 2050 as an immediate transition of the global transport sector to Net Zero CO2 emissions over the same period (IEA, 2022). To reach that goal, countries must quickly transition from overarching commitments to national strategies, policies, and action plans. The IEA's roadmap and policy tools furnish a comprehensive guide for countries aspiring to curtail O&G industry methane leakage.

The IEA also estimates that universal adoption of proven abatement policies would result in a 50% reduction in methane leakage from O&G activities. These measures include a prohibition of non-emergency flaring, the application of mandatory leak detection and repair programs, and the introduction of equipment standards (IEA, 2022).

The Methane Pledge establishes the following package of actions:

- **Transparent Reporting:** Require participating companies to report their methane emissions accurately and in detail, addressing both owned and associated operations.
- **Implementation of Best Practices:** Encourage the adoption of best technological and operational practices to reduce emissions along the entire O&G value chain.
- **Technology Development:** Encourage research and development of innovative technologies for the detection and reduction of methane emissions.
- **Government and Business Engagement:** Motivate governments and businesses to commit to concrete actions to achieve methane reduction targets.

The UN Oil & Gas Methane Partnership 2.0

The Oil & Gas Methane Partnership 2.0 (OGMP 2.0) (Oil and Gas Methane Partnership, 2024) is the United Nations Environment Programme's (UNEP) flagship reporting and mitigation initiative for the O&G sector. It is fully aligned with the Methane Pledge Initiative.

OGMP 2.0 not only improves accuracy and transparency in methane emissions reporting, it also sets a comprehensive standard for the industry (i.e., a measurement-based reporting framework). The initiative, launched at the United Nations Climate Summit, has gained **the active participation of more than 120 companies with assets in over 70 countries, covering 38% of global O&G production, more than 80% of LNG flows, almost 25% of global natural gas transmission and distribution pipelines, and more than 10% of global gas storage capacity.**

The Climate and Clean Air Coalition (CCAC) launched the first methane pledge under the OGMP at the UN Secretary General's 2014 Climate Summit. In November 2020, the original OGMP evolved into the ambitious **OGMP 2.0. UNEP, CCAC**, the European Commission, the Environmental Defense Fund, and 62 O&G companies inaugurated this new phase. OGMP 2.0 defines mechanisms to directly link the measurement of methane emissions with actions to reduce those emissions.

OGMP 2.0 information plays a crucial role in addressing the methane data challenge through UNEP's International Methane Emissions Observatory (IMEO). IMEO, an initiative committed to mitigating methane emissions, established an innovative database of methane emissions verified through empirical evidence. This evidence is gathered by consolidating data from various sources, like company reports that the OGMP 2.0 facilitates, satellite observations, scientific studies on methane measurements, and national registries.

OGMP 2.0 has established the benchmark for transparency in reporting methane emissions. It now stands as the most exhaustive methane emissions reporting framework within the O&G sector. The initiative offers a structured protocol that enables companies to effectively oversee and manage their O&G operations-associated methane emissions.

The OGMP 2.0 reporting framework requires companies to disclose methane emissions from all sources, including owned and non-operated operations across the entire value chain. This requirement ensures unparalleled precision and granularity. Additionally, it enhances credibility by showcasing tangible methane emissions reductions to industry stakeholders.

Satellite Imagery

Satellites play a crucial role in enhancing transparency. They significantly contribute to ongoing efforts aimed at illuminating emissions sources, particularly those associated with substantial leaks. By offering valuable insights into the scale and duration of large leaks worldwide, satellites serve as an essential tool for informing the global community of these issues.

These measurements rely on the use of leak-detecting technology and cross-referenced reports. However, satellite monitoring, while valuable for leak alerts, does not offer information suitable for creating an emissions inventory.

Figure 6

Latin America and Caribbean Methane Emissions Observatory

In the LII OLADE Energy Ministers meeting (2022), participants determined that OLADE member countries would take the following actions to support the effort to curb methane emissions:

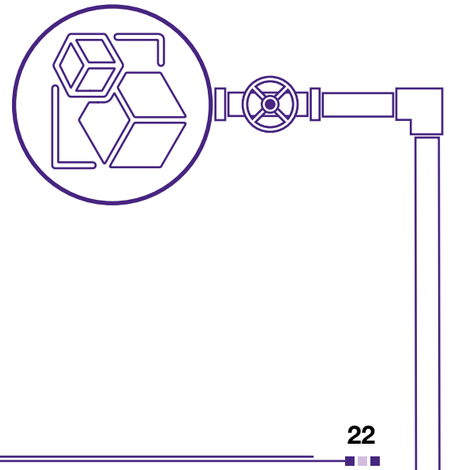
- Create the LAC Methane Emissions Observatory (OEMLAC), (OLADE, 2022)
- **Ensure technical support** to OLADE member countries as they define roadmaps and emissions reduction commitments
- **Provide technical support** in the design and formalization of public policies aimed at reducing methane emissions in the energy sector
- **Develop tools for reporting and verification**
- **Ensure support for oil** and other related companies with state participation
- **Work on standardizing methodologies** and support in the search for and access to financing for the development of projects aimed at reducing methane emissions

Point vi, above, is of particular note because methane reduction initiatives do not have the financing mechanisms for the investment projects that may be required. As such, the restrictions that many multilateral banks apply to projects in the O&G sector constitute a significant barrier to capturing the region's potential for methane emissions reduction. This effect intensifies when we consider the role of the region's NOCs and their capital restrictions.

Lastly, meeting participants also agreed to establish a direct relationship with the International Methane Emissions Observatory and urge member countries to provide that organization with support and relevant information. This decision was the basis for OLADE's current work on an observatory with CAF support and in collaboration with the Global Methane Hub. The observatory will initially seek to internalize the battery of methane reduction tools offered for the LAC region's O&G industry, adopt standards for reporting and monitoring, improve the quality of methane emissions inventory information, work to build capacity, and raise awareness.

The OLADE observatory does not intend to run in parallel with global initiatives. Rather, it will actively contribute to the implementation of its objectives and collection of information. OLADE is the official repository of energy information. It has information on GHG emissions at the regional level, and offers a valid, convenient platform for working on information quality.

> To overcome barriers within the framework of ongoing technical cooperation between CAF and OLADE, workstreams have been established to outline the roadmap toward a low-emissions natural gas (LENG) certification standard and management procedures in LAC nations.



Interconnections and Liquefied Natural Gas: Case Studies

Regional natural gas transportation and interconnections that link suppliers with markets will be a key element of the transition, not to mention accelerating near-term emissions reduction. It can also support economic growth for the region. Over the last 25-30 years, many countries have sought to create such interconnections, with varying degrees of success and maturation, largely due to political legacies and macroeconomic conditions. In this section, we examine some of those linkages and their relevance for a renewed effort to leverage regional natural gas resources and to marry energy and economic security with climate action and decarbonization and emissions reduction.

Redefining Trade: Bolivia's Bold Transformation with Natural Gas Exports to Brazil

The gas integration between Bolivia and Brazil stands as testament to successful bilateral integration between two nations. The emblematic infrastructure project—the Bolivia-Brazil Gas Pipeline, widely recognized as Gasbol—spans approximately 3,150 km; 557 km traverse Bolivian territory, 2,593 km extend through Brazilian territory. Brazil's Transportadora Brasileira Bolivia-Brazil S / A (TBG) manages the pipeline (TBG, 2024).
The integration process began in 1974, with the execution of the "Industrial Cooperation and Complementation Agreement" between Bolivia and Brazil. The agreement signified an initial commitment to supply Bolivian natural gas to Brazil and establish a strategic alliance centered on industrial complementarity. After extensive negotiations, the initial agreement shifted its focus toward gas integration. This shift culminated in the Treaty of La Paz, which was drafted and signed in 1996. This treaty governed the construction and operation of infrastructure, and trade of gas between the two countries. Pipeline construction commenced in 1997; the pipeline's operational launch took place in 1999 (Medinaceli, 2021). In March 2000, the final contractual 30.08 MMmcd pipeline capacity was reached, and the original objective of supplying a significant percentage of Brazil's energy consumption with natural gas was met (Medinaceli, 2021).

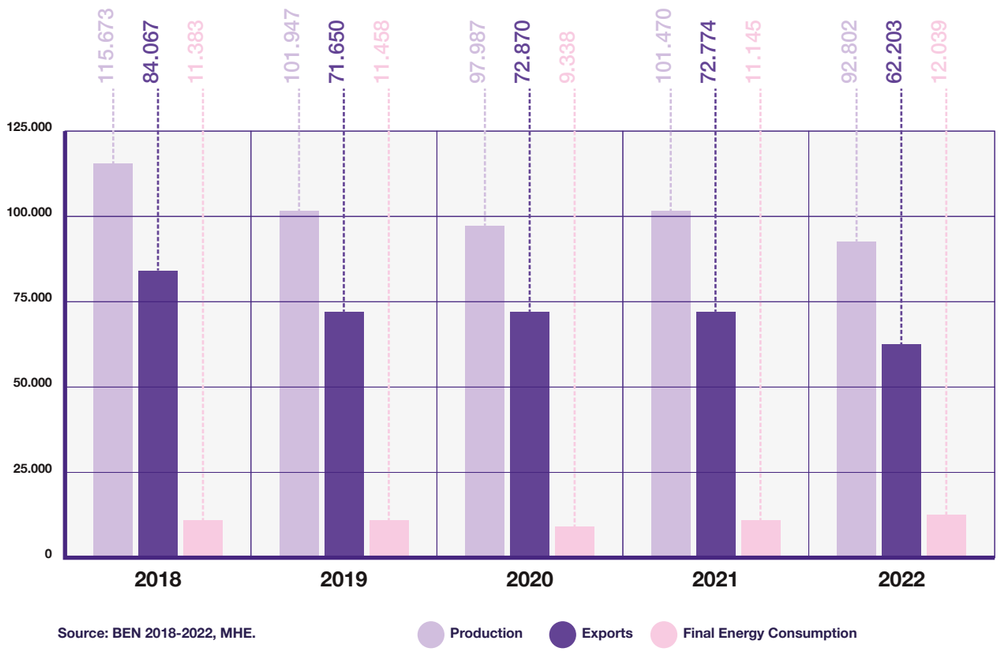
Bolivia's natural gas export profile has played a crucial role in its economic development over the past few decades. **Natural gas exports to Brazil have consistently ranged between 25-30% of Bolivia's total exports (Medinaceli, 2021). In 2022, 67% of Bolivia's gross natural gas supply was earmarked for export.** However, there has been a gradual decline in production, which has led to a drop in exports to Brazil. The 2015 peak value, which exceeded 30 MMmcd, has dwindled to approximately 16 MMmcd (MHE, 2023). Bolivia's total natural gas production dropped 20% between 2018 and 2022.

Until 2017, Bolivia and Brazil adhered to their accord terms seamlessly. Agreed-upon volumes were met with no issue. The slowdown emerged in 2015, as export prices began to decline. In 2018 production limitations exacerbated the problem and Bolivia was unable to fulfill the contracted gas volumes. This non-compliance resulted in fines. Consequently, in December 2019, the eighth addendum to the contract was executed. It introduced modifications to the delivery point and reduced minimum delivery volumes.

Between 2005 and 2014, **over 80% of Bolivian gas** was allocated to Brazil and Argentina; the rest went to the domestic market. But a shift in market composition had begun in the late 1990s. At that time, **approximately 70% of production was exported and 30% kept for domestic consumption.**

Bolivia's natural gas production plummeted between 2015 and 2019, primarily due to a decline in major producing fields San Alberto and Sábalo. Incahuasi field output partially alleviated the decline but could not fully compensate for the overall decrease (Medinaceli, 2021). Bolivia's reduced production capacity and its need to prioritize the domestic market prompted a shift in the composition of Bolivian natural gas demand.

Bolivian Natural Gas Production, Exports and Consumption, 2018-2022 (Kbep)



Source: BEN 2018-2022, MHE.

Figure 7

Bolivia's state-run Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) has now shifted its commercial focus, aiming to diversify its client portfolio in Brazil and forging strategic alliances within its target markets. The Ministry of Hydrocarbons Ministerial Resolution 255/2006 asserts that the current order of supply to Bolivian markets prioritizes the domestic market first, followed by the oldest market, Brazil, and finally Argentina.

Medium-term projections indicate that the supply to the Brazilian market will likely drop below 20 MMmcd, contractually extending until 2026. (Medinaceli, 2021). The development of gas integration with Brazil is believed to have contributed to over half of Bolivia's economic growth in the past 15 years (Medinaceli, 2021). But a highly subsidized domestic market in which ever-increasing volumes have been used to generate electricity at a very low domestic gas benchmark price has gradually diminished Bolivia's exportable volumes in the absence of expanded production capacity. This dynamic has directly impacted royalties and the country's trade balance.

Efforts to develop Brazil's domestic natural gas supply are underway, with the aim to cover import demands from Bolivia with domestic resources or possibly LNG.

Regional Integration of Natural Gas and Electricity Markets in the Southern Cone - Argentina, Chile, Uruguay, and South Brazil

In the 1980s, the Southern Cone's electricity sector achieved significant integration through interconnected hydroelectric power plants that were strategically constructed along binational rivers like the Paraná and Iguazú. Collaborative efforts among Argentina, Brazil, Paraguay, and Uruguay led to the establishment of crucial shared facilities. These endeavors included major binational projects like Itaipú (14 GW), Salto Grande (1.89 GW), and Yaciretá (3.2 GW). These projects were initiated through government efforts and financed by sovereign debt. The ventures played a pivotal role in enabling power systems to interconnect across the 50Hz countries Argentina, Paraguay, and Uruguay, as well as Brazil (a 60 Hz country). National power companies facilitated the coordination of dispatch activities, marking a significant milestone in the regional integration of energy systems.

In the late 1980s and 1990s, Argentina's natural gas resource development advanced significantly. Argentina faced substantial economic challenges during this period, which prompted an extensive reform, and drove the establishment of a new regulatory framework, wide-ranging privatizations, and the opening of the market to private initiatives. Meanwhile, other countries, notably Brazil and Chile, seized the opportunity to capitalize on these emerging gas reserves. Their interest facilitated the creation of essential infrastructure through private initiatives. Key natural gas integration facilities were built, marking a pivotal period in the regional development of energy resources.

The following pipelines were built between 1997 and 2011:[16]

Activated Southern Cone Pipelines, 1997-2011

PIPELINE NAME	COUNTRY	CAPACITY ($x10^6$ Nm^3/d)	ONLINE YEAR	STATUS
Norandino	Chile	4.0	1999	Operating
Gasatacama	Chile	5.4	1999	Idle
Gasandes	Chile	9.0	1997	Operating
Pacifico	Chile	3.5	1999	Operating
Methanex YPF	Chile	2.0	1999	Operating
Methanex SIP	Chile	1.3	1999	Operating
Methanex PAN	Chile	2.0	1997	Operating
TGM	Brazil	2.8	2000	Operating
Cruz del Sur	Uruguay	6.0	2002	Operating
Petro Uruguay	Uruguay	1.0	1998	Idle
Juana Azurduy	Bolivia	22.0	2011	Operating
Pocitos-Campos Durán	Bolivia	7.4	1980	Mothballed
Madrejones-Campos Durán	Bolivia	4.3	1972	Mothballed

Source: The Role of Argentine Gas in The Southern Cone Energy Integration, Henrique Vilela Pinto dos Anjos, 2022

Figure 8

[16]The role of Argentine gas in the Southern Cone energy integration / Henrique Vilela Pinto dos Anjos. – Rio de Janeiro: UFRJ/COPPE, 2022.

In addition to binational power plants and pipelines, the neighboring nations built several electricity interconnections through transmission lines linking Argentina and Chile (Cobos-Andes, 600 MW), Argentina and Brazil (Paso de los Libres-Uruguaiana, 50 MW, and Rincón de Santa María – Itá, 2,100 MW), Argentina and Paraguay (Clorinda-Guarambaré, 80 MW, and El Dorado-López, 30 MW), and Uruguay and Brazil (Melo Converter Stations, 500 MW, and Rivera, 70 MW). The electricity sector has benefited from long lasting cooperation agreements and governments engaged in negotiation to better use their complementary resources.

But between 2004 and 2006, domestic issues drove the Argentine government to cancel export authorizations despite significant investments. The move drastically reduced power and gas volumes exported to Chile, Brazil, and Uruguay. Argentina resumed exporting natural gas to these countries in 2016, but it took until 2022 and 2023 for the country to resume daily exports. Exports have still not reached full capacity.

Argentina Natural Gas Exports to Chile, Brazil, Uruguay, Jan 2023 – Jan 2024

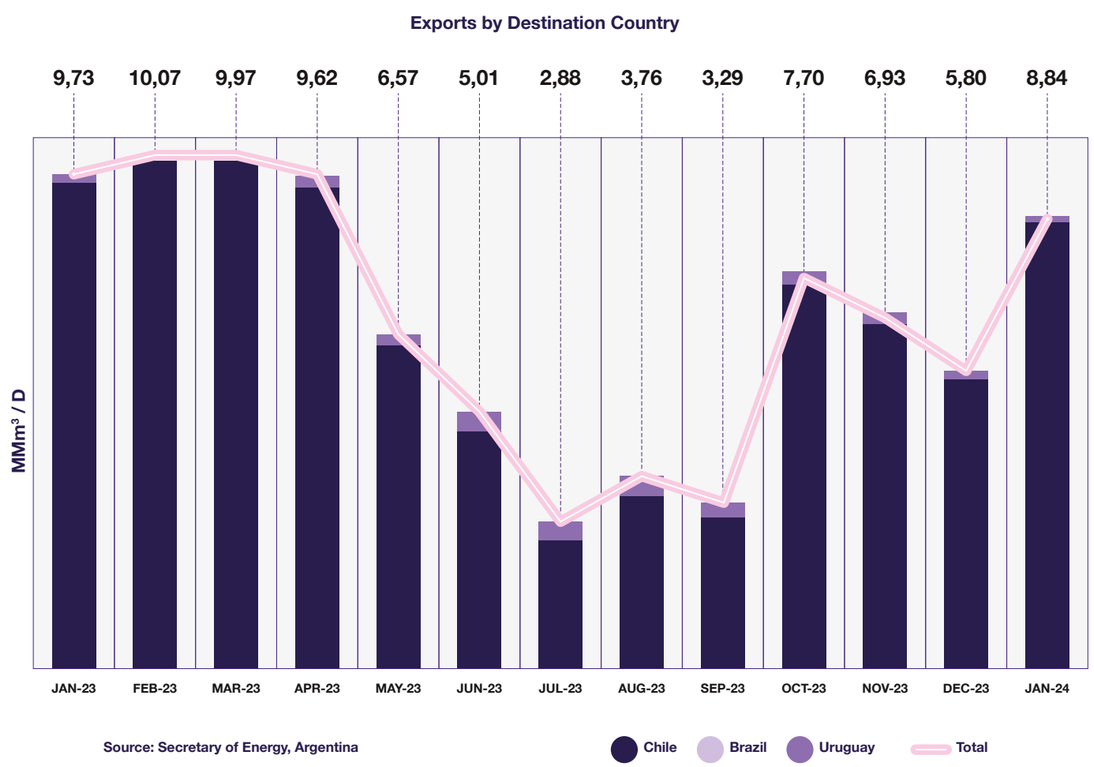


Figure 9

Argentina's natural gas demand varies significantly by season. This variability impacts exports heavily, particularly during the southern hemisphere's winter.

Bolivia's exports to Brazil are on the decline due to falling production and reserves (see above for more). But the infrastructure in Bolivia that has become increasingly "stranded" as a result of those declines will be important for a new wave of natural gas exchanges, particularly from Argentina.

In 2023, Argentina modified its natural gas transportation system to boost Vaca Muerta reservoir production and export opportunities. The Nestor Kirchner pipeline was built in record time to move Vaca Muerta production to Argentina's main demand center, Buenos Aires. The project's second and third phases are underway. Once complete, they will transport Vaca Muerta's production to Chile, Bolivia, and Brazil.

Brazil has also made significant strides in the natural gas sector, most notably its April 2021 approval of the New Gas Law. This legislation sets the stage for a comprehensive reform aimed at promoting competition, efficient resource allocation, and transparent pricing in the natural gas market. This legal and regulatory evolution also includes the initiation of Petrobras's partnership and divestment program in 2015, which created an opportunity to enhance the natural gas sector's institutional framework.

Brazil's 2016 Gas to Grow program focused on increasing competition through infrastructure guarantees and market-oriented rules. Subsequent resolutions in 2019 led to the creation of the New Gas Market program, which addresses elements like promoting competition, harmonizing rules, integrating with other sectors, and removing tax barriers.

Additionally, the Committee to Monitor the Unbundling of the Natural Gas Market (Comitê de Monitoramento da Abertura do Mercado de Gás Natural - CMGN) was established to monitor the natural gas market, and the Conselho Administrativo de Defesa Econômica (CADE) came to an agreement with Petrobras to end the latter's de facto monopoly. Various institutional players, including government ministries and regulatory bodies, continue to actively contribute to these initiatives.[17] While this process is taking time, private companies are positioning themselves to embark on long term investments in pipelines, distribution networks, gas field exploitation, and LNG terminals.

The Southern Cone is entering a new phase of energy integration amidst the following realities:

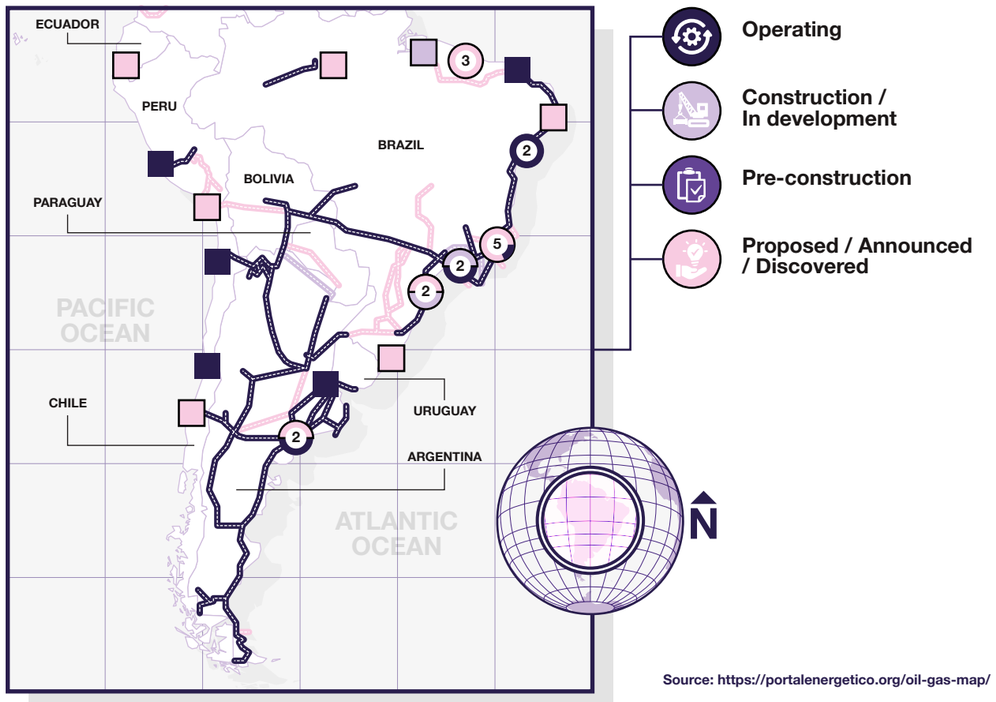
- Bolivia's fields are at depletion, which limits the country's ability to export the full capacity of existing pipelines.
- Brazil is rapidly developing its local market and promoting a liberalization of the market to boost natural gas demand over liquid fuels and coal.
- Argentina is repositioning itself as a South American gas leader, based on huge unconventional resource reserves.
- Uruguay, a leader in renewable energy integration with nearly 100% reliance on hydro, wind, and solar energy, still struggles to reduce its consumption of liquid fuels and LPG; it needs additional infrastructure development.
- Chile, currently reliant on Argentina and global sources through two LNG regasification terminals, is poised to play a pivotal role in the region's energy transition. Despite a push for a 100% renewables grid with zero emissions, natural gas remains essential for sectors that cannot be easily electrified.

[17] Implementing Gas Market Reforms in Brazil, IEA (https://www.iea.org/reports/implementing-gas-market-reforms-in-brazil)

The map in Figure 10 illustrates current and potential new gas pipelines to interconnect gas fields and meet new demand sources. The "extended" Southern Cone, in particular, has an important project in its portfolio that is slated to bring natural gas to new geographical areas to replace other, more pollutant fossil fuels as well as create new demand.

For example, the Gasoducto al Sur Peruano (Gas Pipeline to Southern Peru) would supply efficient power generation, replace diesel oil, and allow for the reconversion of industries to natural gas (and encourage new ones). A pipeline connecting Uruguayana, Brazil with Porto Alegre (also in Brazil) would close a "ring" to supply domestic demand in that country with either Argentine or Bolivian natural gas. That supply would boost reconversion of industries in the broader area encompassing Porto Alegre and Curitiba. Another potential routing to supply Porto Alegre is to connect this city with Montevideo, bringing natural gas to the south of Brazil. A pipeline to Paraguay has long been considered, though there has yet to be enough real demand to justify its construction.

Current and Future Natural Gas Network in the Southern Cone



Source: https://portalenergetico.org/oil-gas-map/

Figure 10

Evolution of Natural Gas Production in the Southern Cone (1995 – 2022)

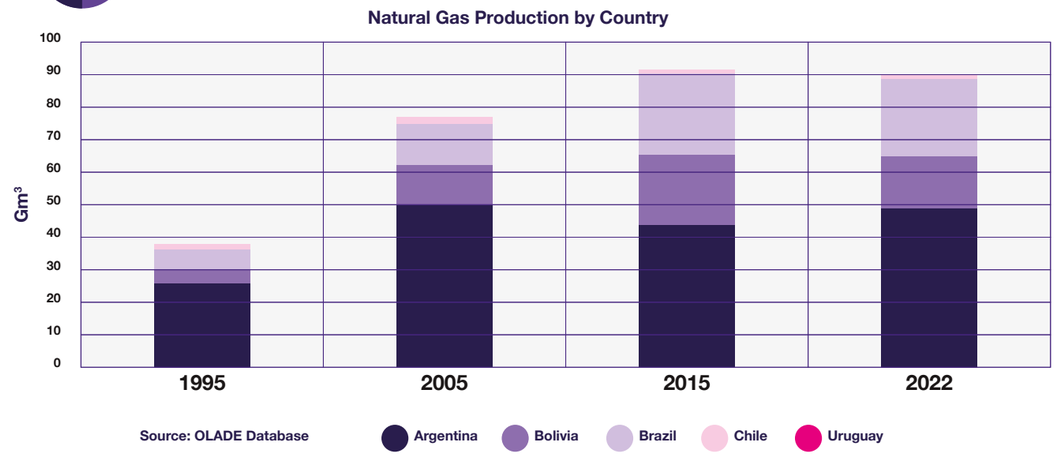


Figure 11

Evolution of Natural Gas Demand-Supply Balance per country 1995 - 2022

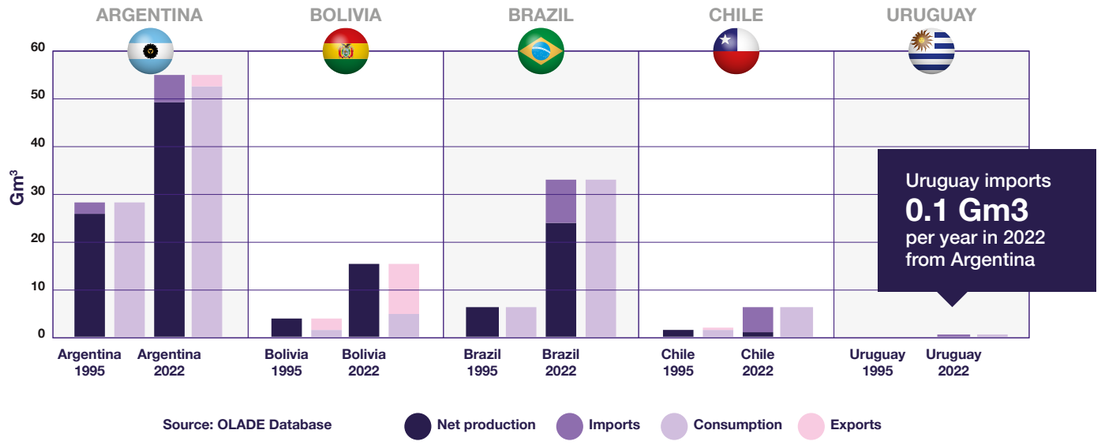


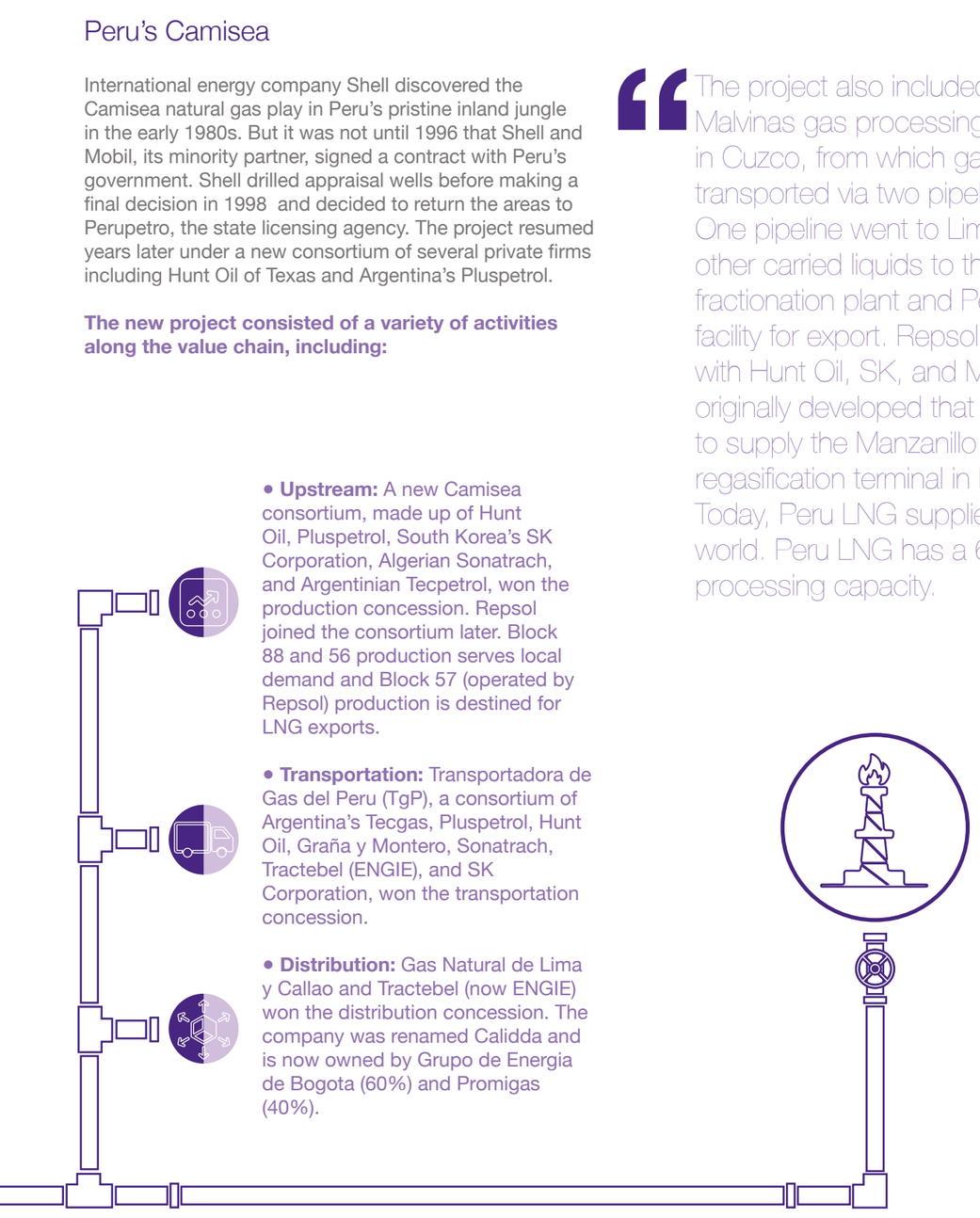
Figure 12

Peru's Camisea

International energy company Shell discovered the Camisea natural gas play in Peru's pristine inland jungle in the early 1980s. But it was not until 1996 that Shell and Mobil, its minority partner, signed a contract with Peru's government. Shell drilled appraisal wells before making a final decision in 1998 and decided to return the areas to Perupetro, the state licensing agency. The project resumed years later under a new consortium of several private firms including Hunt Oil of Texas and Argentina's Pluspetrol.

The new project consisted of a variety of activities along the value chain, including:

> The project also included the Las Malvinas gas processing station in Cuzco, from which gas was transported via two pipelines. One pipeline went to Lima, the other carried liquids to the Pisco fractionation plant and Peru LNG facility for export. Repsol (together with Hunt Oil, SK, and Marubeni) originally developed that facility to supply the Manzanillo LNG regasification terminal in Mexico. Today, Peru LNG supplies the world. Peru LNG has a 625 mmcfd processing capacity.

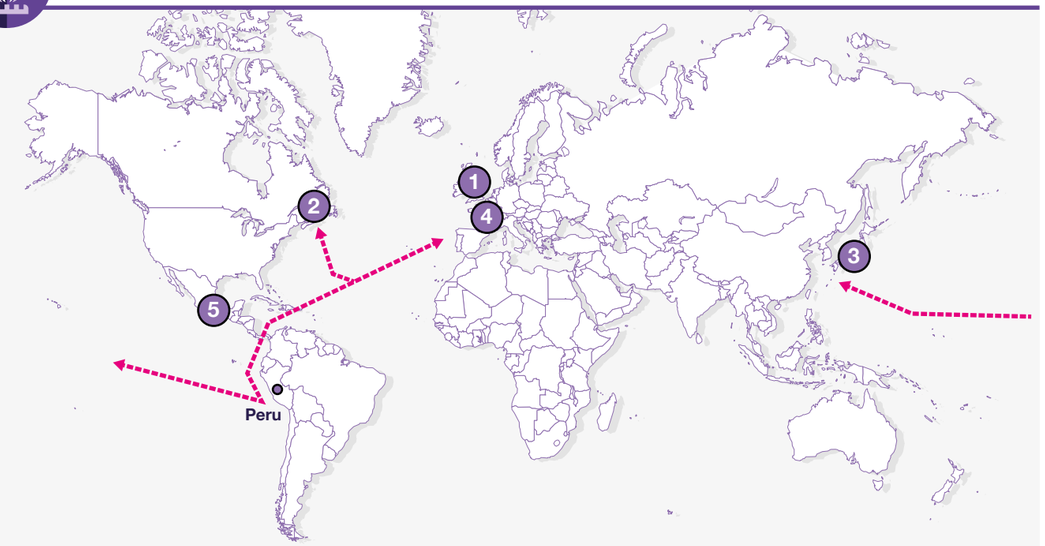


- **Upstream:** A new Camisea consortium, made up of Hunt Oil, Pluspetrol, South Korea's SK Corporation, Algerian Sonatrach, and Argentinian Tecpetrol, won the production concession. Repsol joined the consortium later. Block 88 and 56 production serves local demand and Block 57 (operated by Repsol) production is destined for LNG exports.

- **Transportation:** Transportadora de Gas del Peru (TgP), a consortium of Argentina's Tecgas, Pluspetrol, Hunt Oil, Graña y Montero, Sonatrach, Tractebel (ENGIE), and SK Corporation, won the transportation concession.

- **Distribution:** Gas Natural de Lima y Callao and Tractebel (now ENGIE) won the distribution concession. The company was renamed Calidda and is now owned by Grupo de Energia de Bogota (60%) and Promigas (40%).

Peru LNG Exports, 2023 (m3)



1 United Kingdom 1 330 197,00 m^3
2 Canada 170 319,34 m3
3 Japon 167 546,81 m3
4 France 156 924,99 m3
5 Mexico 166 625,82 m3

Source; Perupetro, 2023

Figure 13

The project's three stages—**upstream, midstream and downstream**—were expected to require a US$ 3 - 4 billion combined investment. Considerable funding was obtained from the Export-Import Bank of the United States (US$ 210 million) and Citibank Group (US$ 120 million) for the upstream portion. An array of smaller commercial banks and organizations provided further financing.[19]

With an initial 400 million cubic feet (mcf) (11.3 million cubic meters "mcm") of natural gas and liquids production per day, Camisea has continuously expanded ever since it started operations. The project now produces 1.715 mcf (48.6 mcm) per day, which allows it to supply Lima, Callao, Ica, and Marcona demand, and export LNG.[20]

The TgP pipeline had an initial ~205/314 mcf (5.8/8.9 mcm) capacity. It was also expanded in 2016, to hold 920 mcf (26 mcm).[21]

The development of the Camisea Gas Project introduced a transformative phase in Peru's energy landscape. We review several of the key changes below.

[19]10 years of Camisea: The Natural Gas Revolution in Peru. https://theenergyyear.com/articles/10-years-of-camisea-the-natural-gas-revolution-in-peru/
[20]Boletín Estadístico OSINERGMIN 4to Trimestre 2023.
[21]Boletín Estadístico OSINERGMIN 4to Trimestre 2023.

Increased Energy Demand

• **The extraction and utilization of natural gas from the Camisea fields provided a new, abundant energy source for Peru.** Natural gas gained prominence as a cleaner, more efficient alternative to traditional energy sources, which led to a heightened demand for energy across Peru's economy.

• **The availability of natural gas played a key role in fueling industrial and commercial activities.** Industries increasingly turned to natural gas for manufacturing, power generation, and heating, which contributed to the country's overall economic expansion.

• **Greater natural gas availability played a crucial role in meeting Peru's increased energy demand, especially in the transportation sector.** Natural gas-powered vehicles (NGVs) gained popularity as a cleaner, cost-effective alternative to traditional gasoline and diesel-powered vehicles.

Diversification of Energy Sources

• **A gradual shift from traditional and often more polluting energy sources took hold as natural gas became more available.** This diversification helped improve the sustainability of Peru's energy matrix and aligned it with global trends toward cleaner, more environmentally friendly energy options.

Infrastructure Development

• **New and enhanced gas infrastructure, including pipelines and distribution networks, became a necessity.** This infrastructure development not only facilitated the efficient transport of natural gas but also laid the foundation for the broader accessibility and utilization of this energy resource.

Economic Impacts

• **The expansion of the energy sector, driven by the Camisea Gas Project,** generated employment opportunities and contributed to overall economic growth. The development of the project and associated infrastructure efforts stimulated economic activities in the regions surrounding the Camisea fields.

Energy Security and Independence

• **By tapping into the domestic natural gas reserves offered by Camisea,** Peru was able to reduce its reliance on energy imports. This shift enhanced energy security, and the country developed a more self-sufficient and resilient energy framework.

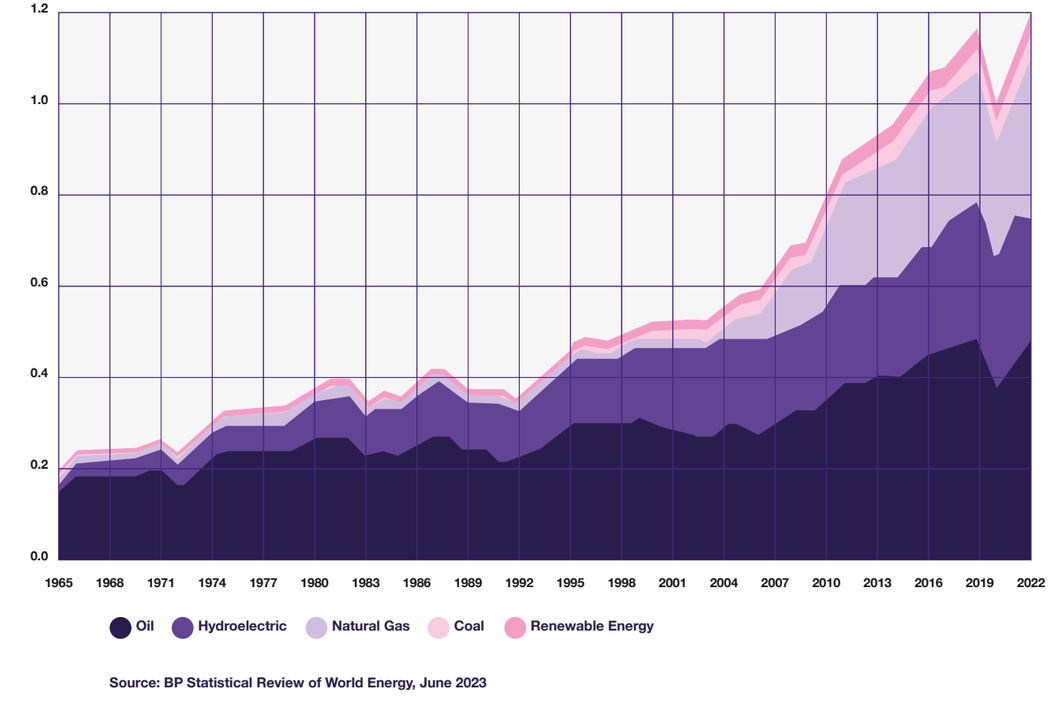
Environmental Benefits

• **Natural gas combustion produces less carbon dioxide (CO_2) than coal and oil.** By promoting the use of natural gas, particularly in power generation and transportation, Peru has contributed to a reduction in overall GHG emissions, mitigating its impact on climate change.

• **NGVs are known for their lower emissions compared to traditional vehicles;** they help improve air quality and reduce environmental impact. The integration of NGVs aligns with global efforts to address climate change and promote sustainable transportation solutions.

> Ultimately, the Camisea Gas Project drove a paradigm shift in Peru's energy matrix. It catalyzed growth, promoted sustainability, and fostered greater energy independence through the strategic development and utilization of natural gas resources.

Peru Energy Consumption, 1961-2022



Source: BP Statistical Review of World Energy, June 2023

Figure 14

Peru Energy Consumption by Share, 1965-2022

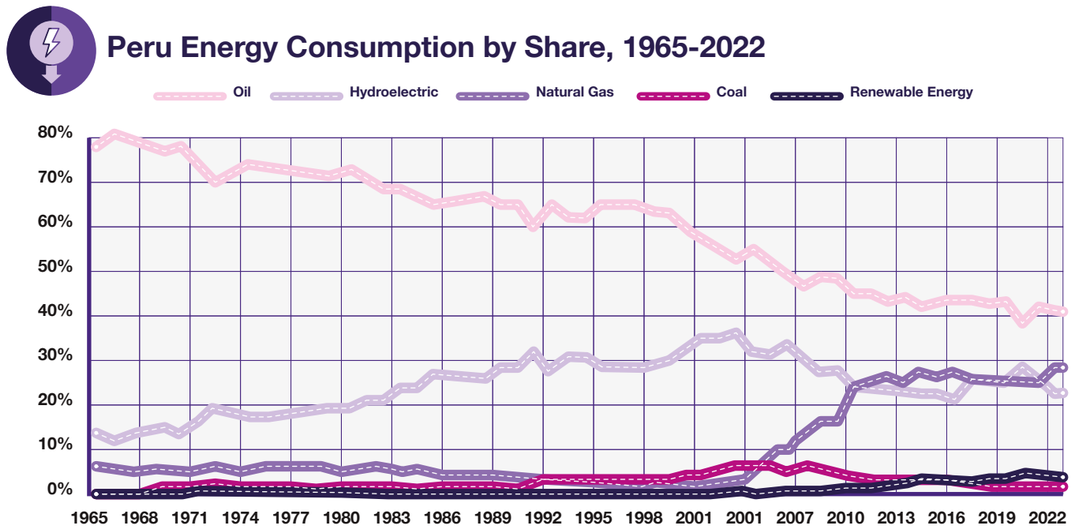


Figure 15

Trinidad & Tobago and Venezuela

Established in August 1975, the National Gas Company of Trinidad and Tobago Limited (NGC) has played a pivotal role in the nation's energy landscape since its inception. From the outset, NGC has been dedicated to the development and utilization of natural gas resources, with a primary focus on the construction and operation of natural gas pipelines.[22]

The Atlantic LNG Company of Trinidad and Tobago, formed in 1995, has worked alongside NGC to establish the country as a formidable presence in the LNG market. Atlantic LNG commenced operations in 1999 with the inauguration of Train 1, which was the largest of its kind globally at the time. Since then, Atlantic has expanded its operations to encompass four trains, boasting a combined capacity of 15 million metric tons per annum (mtpa).[23] This substantial capacity underscores Trinidad and Tobago's (T&T) emergence as a prominent global LNG exporter. But domestic supply issues have caused the industry to suffer and have increasingly cast doubt on the future of T&T's LNG export capacity, as well as its petrochemical industry. Indeed, there are important natural gas reserves and production concerns that must be addressed.

According to S&P Global's assessment, T&T became the Caribbean's largest oil and gas producer with a 4 Bcf/d production in 2010. That production has since declined to 2.6 Bcf/d. The fall has continued, but there are projects under development that could arrest it, including the Manatee and Calypso field.[24] However, most attention of late has focused on the link with Venezuela's Dragon field (see below for more).

[22]The Natural Gas Company of Trinidad and Tobago. "Early Years of Operation" 2024. Early Years of Operation | NGC

[23]Atlantic LNG. "Atlantic History" 2024. History - Atlantic LNG

[24]Anjos, Mariana and Vargas Ortega, Stephanie. "Arresting the decline: Trinidad and Tobago's natural gas supply alternatives" S&P Global Commodity Insights. Feb 21, 2024. https://www.spglobal.com/commodityinsights/en/ci/research-analysis/arresting-the-decline-trinidad-and-tobagos-natural-gas-supply-.html

Today, T&T is the region's largest LNG exporter. Peru stands as its sole regional competitor. Yet the Caribbean remains dependent on fuel and diesel for energy production. T&T has been looking to expand its operations to make LNG exports to its LAC neighbors more accessible. Currently the U.S., China, and Spain are the largest consumers of T&T's LNG production.[25]

The recent licensing of activities in the Dragon field could catalyze this expansion and help T&T maintain its title as the region's largest LNG exporter. The field, which lies on the national maritime border between T&T and Venezuela, is the first natural gas project to come to fruition in some time for the Latin American country. The U.S. government lifted some sanctions on Venezuela and PDVSA in 2023, which allowed Shell and NGC to obtain leasing rights to drill for and process Dragon field natural gas. Venezuela is not an operational partner. It only receives rents. The deal was secured because the T&T NOC will be the primary producer/processer. Shell is the extraction partner. This is an ideal arrangement, as Venezuela lacks the infrastructure to process its natural gas into LNG but has enormous reserves.

T&T and Venezuela have a symbiotic relationship. Separated by only seven miles of ocean, the decline of and restrictions on Venezuelan O&G production has impacted T&T's LNG production.

> "The Dragon field contains an estimated 3.2 trillion cubic feet of natural gas. It could offer stability for T&T as it has the potential to provide about half of the country's 700 mmcfd domestic demand. In addition, as Reinaldo Quintero, president of Argos Energy Services, told Forbes, "Overall, we are talking about recovering 14,000 jobs in the small island nation." [26]

[25]Trinidad and Tobago NGL Limited. "T&T's Energy Sector" 2021. T&T's Energy Sector | Trinidad and Tobago NGL Limited

[26]Ferrer, Elias. "Shell, Trinidad, Venezuela to Exploit Dragon Gas Field" Forbes. Dec 22, 2023. Shell, Trinidad, Venezuela to Exploit Dragon Gas Field (forbes.com)

Stranded Assets

The financial requirements for transitioning a significant portion of industries toward carbon neutrality or non-emitting manufacturing facilities poses a formidable challenge. The goal may be unattainable for some. While the energy and transportation sectors have made notable strides, as have certain heavy industries like mining, steel, and cement, overall industry conversion faces economic constraints that necessitate careful consideration and strategic planning.

Stranded assets in the context of the energy transition refers to assets or investments, particularly those of the fossil fuel industry, that may become uneconomical or obsolete due to changes in the energy landscape, policies, market shifts, or technological advancements. Investments in natural gas infrastructure assets face the challenge of becoming stranded in about 10 to 20 years, while their useful lifetime should be closer to 30+ years. There are other negative impacts of abandoned infrastructure in the O&G sector, as well.

The industry continues to debate complementarity or use of natural gas pipelines and networks to transport hydrogen. Some companies have tested such use with satisfactory results. In Europe, eight companies from six countries (DGC, Electrolux, BDR, Gas.Be, CEA, GWI, DVGW-EBI, and GERG) worked together on the Testing Hydrogen Admixtures for Gas Appliances (THyGA) project[27] over the course of 30 months. Engie coordinated the project. The consortium included laboratories, companies from across the gas value chain, manufacturers representing various applications (e.g., cooking, heating), and an international association. The project concluded in June 2023 with some important insights, as reviewed in Figure 16.

THyGA Conclusions

Source: THyGA, 2023 • Figure 16

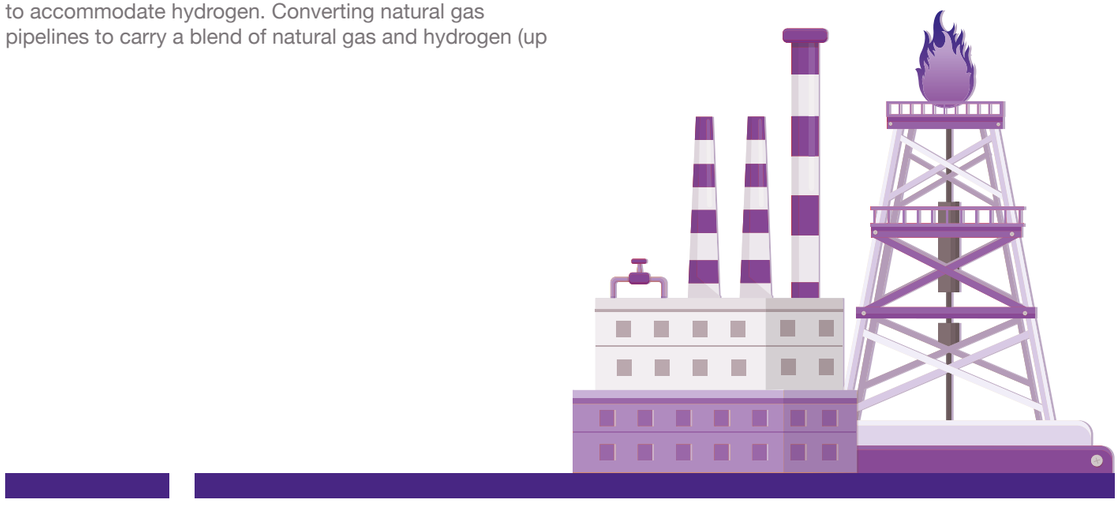
Source: https://thyga-project.eu/

It will take further research to determine whether the whole gas network and its components can support the replacement of natural gas with hydrogen.

In the case of LNG, the European Union has begun to construct multiple new LNG terminals to ramp up gas imports from faraway sources like the United States and Qatar. Hydrogen import-export projects are already underway in some of the top LNG importing countries of the Asian Pacific, like South Korea and Japan. Importers in Europe and the Asian Pacific are branding this build-out as consistent with climate targets, claiming that their LNG terminals are "hydrogen-ready"—i.e., they could eventually be converted to accommodate hydrogen and cease using fossil fuels. As previously noted, the EU has also enacted key legislation and policy directives to decarbonize gas markets and a carbon border adjustment mechanism to apply more broadly.

But these developments highlight the need to explore what "hydrogen-ready" actually means (and what it doesn't) in the context of LNG, along with the implications of such a transition. Technical uncertainties and risks associated with reconversion projects must be analyzed on a case-by-case basis.[28] Hydrogen delivery infrastructure could be rapidly expanded by adapting part of the natural gas delivery infrastructure to accommodate hydrogen. Converting natural gas pipelines to carry a blend of natural gas and hydrogen (up to ~15% hydrogen) could require only modest pipeline modifications. Converting existing natural gas pipelines to deliver pure hydrogen would likely require more substantial modifications. Current research and analyses are examining both approaches.[29]

The future of natural gas remains undefined. There are compelling reasons to explore its development and enhance existing infrastructure as integral components of the journey toward decarbonization. Natural gas is currently the cleanest fossil fuel. According to the U.S. Energy Information Administration, "About 117 pounds of CO2 are produced per million British thermal units (MMBtu) equivalent of natural gas compared with more than 200 pounds of CO2 per MMBtu of coal and more than 160 pounds per MMBtu of distillate fuel oil. The clean burning properties of natural gas have contributed to increased natural gas use for electricity generation and as a transportation fuel for fleet vehicles in the United States,"[30] and in some Latin American countries, like Argentina, Peru, Brazil. Natural gas offers efficient utilization of installed capacity and demands comparatively less (though not negligible) investment to facilitate its widespread adoption. It is a strategic stretch of the road to decarbonization in the near and medium term, until at least 2050.



[28]Source: https://www.nrdc.org/bio/ade-samuel/hydrogen-ready-lng-infrastructure-uncertain-way-forward.

[29]Source: https://www.energy.gov/eere/fuelcells/hydrogen-pipelines. Also check for more information and points of view: https://www.energy.gov/eere/fuelcells/hyblend-opportunities-hydrogen-blending-natural-gas-pipelines or https://climate.mit.edu/ask-mit/can-we-use-pipelines-and-power-plants-we-have-now-transport-and-burn-hydrogen-or-do-we-need.

[30]Source: https://www.eia.gov/energyexplained/natural-gas/natural-gas-and-the-environment.php#:~:text=Natural%20gas%20is%20a%20relatively,an%20equal%20amount%20of%20energy

Latin American National Oil Companies' Decarbonization Strategies: An Assessment

Across the globe, but particularly in LAC countries, the state plays a key role in the energy sector, principally by way of state-owned enterprises. This dynamic is most notable with NOCs. These state-owned enterprises (SOEs) have exercised what the Baker Institute's Francisco Monaldi calls a "dominant force."[31]

Monaldi, a Venezuelan energy economist focused on the intersection of politics and policy in the Western Hemisphere, has written extensively about resource nationalism. His research shows that NOCs control more than 70% of the world's oil reserves, which, he points out, is the result of a major shift from the 1960s, when private companies controlled almost 80% of global reserves.[32]

Indeed, a recent CSIS research paper published following COP28 offered a similar summary of this inflection point. The paper further notes that NOCs "produce about half of the world's oil and gas and play a critical role in the global economy."[33] The creation of OPEC in the 1960s, along with a major shift toward resource nationalization and a drop in oil majors' control (particularly the oil majors knows as the "seven sisters") led to what CSIS called "a tumultuous period" with "political and economic drivers" that sparked the nationalization wave.[34]

Argentina's YPF was the world's first NOC. It was formed in the 1920s. Mexico's Pemex arrived in the 1930s. Brazil's Petrobras and Venezuela's PDVSA came much later but have played major roles in energy development and their countries' economic fortunes ever since.

Given this history, NOCs tend to play an outsized role in domestic energy policymaking. Their role in the energy transition and the global climate debate will also be key. As the CSIS paper states, "National oil companies play a unique role in the global energy system, and charting the long-term shift away from fossil fuels means grappling with the role of these companies and with oil- and gas-dependent states more broadly."[35]

To assess key LAC NOCs, we created a series of questions and areas for consideration and analysis, as follows:

- What are their Net Zero commitments, and by what year?
- Where are they in the process?
- What about development of low carbon fuels (sustainable aviation fuel (SAF), e-fuels, advanced biofuels)?
- Where are they on carbon capture and sequestration?
- What are their other areas of research and investment (renewables, especially offshore wind; nature-based solutions/offsets)?

[31] "The Cyclical Phenomenon of Resource Nationalism in Latin America." Francisco J. Monaldi, March 31, 2020, Oxford Research Encyclopedias. https://doi.org/10.1093/acrefore/9780190228637.013.1523

[32] Ibid

[33] "National Oil Companies, Climate Commitments, and Methane." Brief by Ben Cahill and Kjersti Swanson, December 13, 2023, Center for Strategic and International Studies (CSIS)

[34] Ibid

[35] Ibid

Many of these questions have binary, and, frequently, quantitative answers. Our research included a literature review focused on a wide range of local and international sources, institutions, and, when possible, company data. For those NOCs that included publicly available data, we relied upon their SEC filings to respond to the above-listed queries. Additionally, annual corporate reports, sustainability reports, and several third-party reports were reviewed to allow for a fuller picture and assessment.

Our research and analysis pointed to a rather clear delineation between most of the region's NOCs. But the LAC region encompasses a large and diverse number of countries. When it comes to culture, populations, language, economics, and, of course, natural resources and energy, the heterogeneity is crystal clear.

The 2023 IEA outlook report on the region captures these facts and highlights what they call "the door to future opportunities" (Figure 17). "Opportunity" is the defining concept behind LAC's role in the global energy transition. By extension, the concept applies to key NOCs, where they fit, what role they will play, and what they should consider as they continue to act as the "dominant force" that Francisco Monaldi ascribes them.

LAC Natural Resource Potential

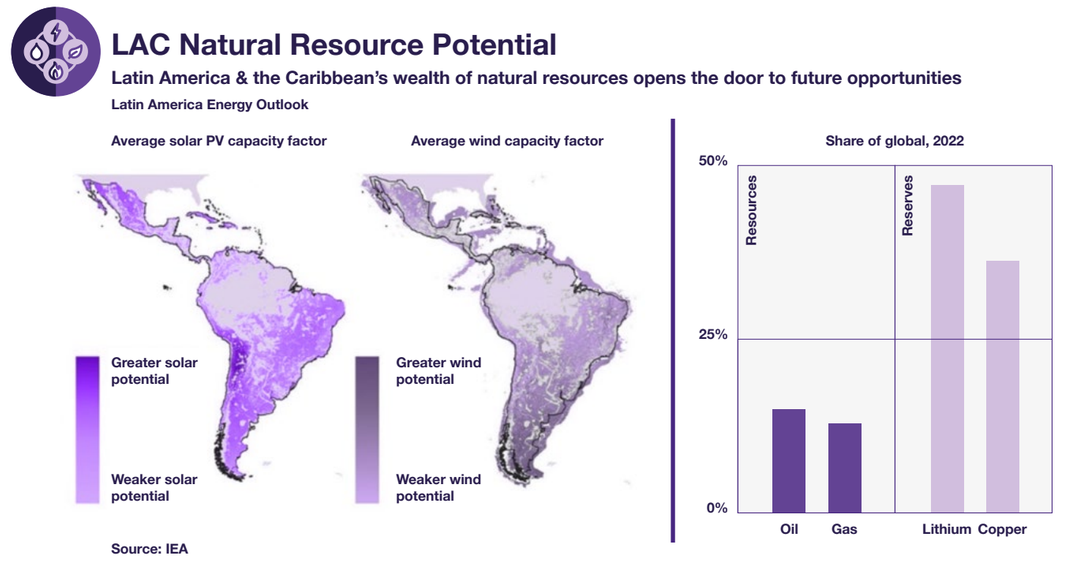


Figure 17

LAC NOCs range from those with major oil and gas reserves and production to those that primarily serve as fuel distributors and retailers, to those that have not only set forth decarbonization goals but have also begun to invest in renewables and climate action. Our analysis points to three distinct ways to assess how LAC NOCs are embracing the climate challenge and leveraging their region's resources and opportunities.

The NOCs can generally be grouped into the following three categories:

- Early Adopters Seizing the Moment
- Developing a Strategy to Seize the Moment
- Incomplete at the Moment

We explore these groupings and some key examples in the following pages.

Early Adopters Seizing the Moment

These NOCs have taken decisive action to support or drive national goals and energy transition policy pathways. They have set clear Net Zero timelines and strategic plans to support Paris Agreement targets. They have also begun to invest significant portions of their budgets in electricity, renewable energy, and alternative fuels, as well as emerging and evolving technologies like carbon capture and sequestration.

The NOCs that fall into this category include:

- Ecopetrol (Colombia)
- ENAP (Chile)
- ANCAP (Uruguay)

> These early adopters still have plenty of ground to cover before they reach Net Zero targets. They still have to make several technology reformulations and important strategic investments, among other things. These NOCs' financial health, along with their decisions to redeploy capital (their own and borrowed) aimed at this transformation will help indicate their progress down the transition path, and determine whether they remain in "Early Adopters" category or not. It is imperative that these NOCs receive government support, regardless of who holds office. Efforts to transition should fall under the umbrella of long-term state policy.

Colombia's Ecopetrol: Strategic Planning and Good Governance Achievements

In March 2021, Ecopetrol announced its commitment and plan to achieve Net Zero carbon emissions by 2050 (Ecopetrol, 2021), as per its energy transition and climate change mitigation objectives. With that, the NOC became the first LAC O&G company to establish such a goal. The company also ratified its responsibility in accordance with the UN's Sustainable Development Goals (SDGs) and the Paris Agreement

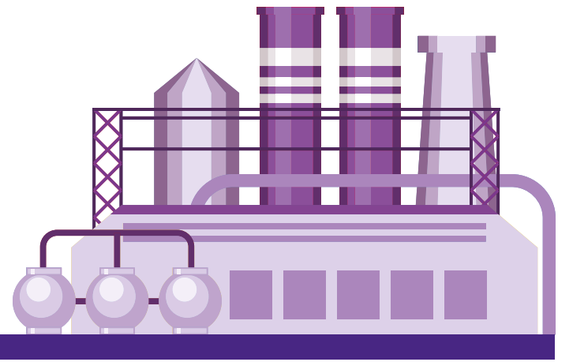
Ecopetrol has since set forth a clear roadmap and launched an open innovation strategy to introduce its "TESG" concept, which incorporates technology into ESG practices, to address key issues like emissions reduction, decarbonization, and water consumption.

The 2050 objective has intermediate goals and a short, medium, and long-term portfolio of projects. Some projects have been implemented; some are in the research stage. By 2030, Ecopetrol seeks to reduce its CO_2 emissions by 25% compared to a 2019 baseline. This move would represent a five-to-six-million-ton CO_2 emissions drop during this decade (Ecopetrol, 2021). That decline would contribute close to 50% of the Colombian energy/mining sector's reduction goal by the year 2030. Ecopetrol also seeks to reduce its total emissions by 50% by 2050. That goal aligns with Colombia's revised nationally determined contributions (NDC) commitment, which sets a more ambitious mitigation target of emitting no more than 169.4 $MtCO_2e$ by 2030, equivalent to a 51% reduction in emissions compared to a revised 2030 baseline (Ministerio de Ambiente y Desarrollo Sostenible de Colombia, 2020).

Ecopetrol's corporate strategy, TESG agenda, and roadmap to promote an energy transition include its proposed goals under a detailed decarbonization plan that seeks to diversify the company's portfolio toward low-emissions business options.

The decarbonization plan includes the ongoing update of Ecopetrol's GHG emissions inventory, the implementation of an emissions reduction portfolio, and the definition of the roadmap to achieve the Net Zero emissions goal. It also includes the design and execution of an offset portfolio that involves natural climate solutions like deforestation prevention and restoration and reforestation via agroforestry projects, among others.

In the short and medium term, the plan will be complemented by a portfolio of natural climate solutions, as well as biomass initiatives and the development of solar, wind, and geothermal energy projects.
In the long term, Ecopetrol plans to develop initiatives related to hydrogen; carbon capture, use and sequestration (CCUS); and energy storage through batteries as these alternatives become competitive and effective. The company has already begun research and pilot projects to determine the potential for green hydrogen production as per the Colombia Hydrogen Roadmap (Ministerio de Minas y Energía Colombia, 2022).



Net Zero Emissions Roadmap and Greater Competitiveness and Resilience

Ecopetrol's Net Zero roadmap sets clear objectives that seek to achieve the following goals:

• Reduce GHG emissions in operations and along the value chain

• Reduce operations' vulnerability to climate change effects

• Adequately manage risks and identify opportunities associated with climate change and the energy transition

Ecopetrol considered currently available mature technologies and emerging technologies with favorable prospects to define the actions to support its short-term sustainability and energy transition goals. The company developed an emissions reduction potential and cost-effectiveness analysis for the short term (2025), medium term (2030), and long term (2050).

The key steps for achieving its short-term strategy include:

• Continually update the emissions inventory from direct operations, subsidiaries, and non-operated assets, including those associated with Scope 3 (Scope 3 emissions are those that come from activities from assets that the reporting entity does not own or control)

• Implement identified initiatives for energy efficiency, and reduction of leakage, venting, and flaring

• Deploy renewable energy options (solar, wind, geothermal)

• Identify additional initiatives for efficiency, flaring reduction, and biomass usage

• Develop the Natural Climate Solutions (NCS) portfolio (NCS include actions to protect a healthy ecosystem, improve working lands management, and restore land and coastal ecosystems)

• Launch a green hydrogen pilot

The key activities for achieving their medium-term strategy include:

• Implement additional technological options to increase energy efficiency, reduce leakage, venting, and flaring, replace polluting fuels, and deploy renewable energy options (solar, wind, geothermal)

• Further develop Natural Climate Solutions portfolio

• Gradually escalate green hydrogen and CCUS pilots (if technologies are competitive)

The key actions for achieving their long-term strategy include:

• Capitalize on technological advancement of competitive initiatives in green hydrogen, carbon sequestration, and renewable energy with battery storage

• Further develop the Natural Climate Solutions portfolio

In addition to the projects and initiatives to reduce emissions, the Ecopetrol Net Zero Road Map includes a comprehensive analysis of the following options:

• Increase the share of gas in the Group's portfolio

• Redirect refining streams toward petrochemicals according to value added

•Replace gasoline and diesel with renewable hydrogen

• Deploy low-carbon fuels

• Manage emissions across the supply chain

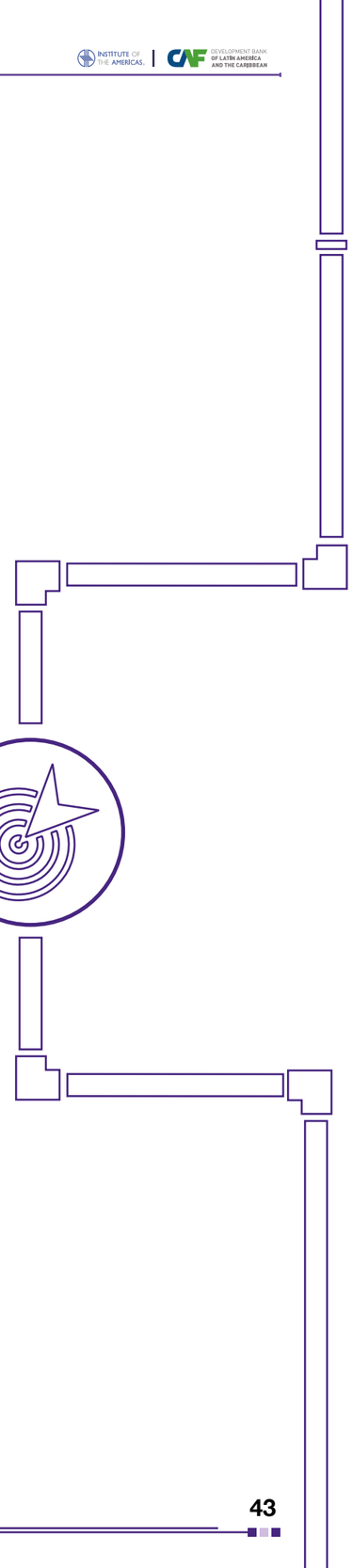
Progress Toward Established Goals

Ecopetrol has hit some road bumps on its way to a more renewable portfolio, particularly with project implementation and deadlines for awarded projects. But it has also made significant progress in the development and implementation of its solar projects. It has three solar plants (Brisas, Castilla, and San Fernando) that it developed in association with other companies (Ecopetrol subsidiaries, AES). Those PV plants provide electricity to the company's operations, helping it toward its goal of connecting 900 megawatts of renewable energy to its operations before 2025 (Ecopetrol, 2023).

Implementation of the hydrogen strategy has also begun. A 50-kilowatt proton exchange membrane (PEM) electrolyzer and 270 solar panels have started operations at the Cartagena refinery. Thus, Colombia's first pilot project for the production of green hydrogen has begun (Ecopetrol, 2022).

Leadership and Governance to Support Sustainability Goals

To support the company's Net Zero and decarbonization goals, Ecopetrol has created three VP-level offices focused on sustainability. Ecopetrol also has an innovative governance structure for an NOC, due largely to its partial privatization under the energy reforms of the early 2000s (the Colombian state maintains more than 80% ownership). Its international shareholders and stakeholders have fostered the definition of a clear sustainability strategy and the identification of a corporate value proposition to support transition and decarbonization efforts; the company has capitalized on that effort. Indeed, Ecopetrol has incorporated governance and reporting practices that are aligned with the best ESG practices of international O&G companies. And the company has also been identified as an executing arm for a good portion of Colombia's proposed environmental policies. Ecopetrol is effectively and functionally coupled with these national policies.



Chile's ENAP: Alignment in Policy and Strategic Planning

Chile's NOC, ENAP, is a pivotal actor in the country's southernmost region, Magallanes. ENAP aligns itself with Chile's ambitious climate goals through a comprehensive plan to achieve decarbonization by 2040 and zero emissions by 2050. The ENAP 2040 strategy, implemented in 2022 and 2023, serves as the driving force behind the company's transformative decarbonization efforts.

ENAP's strategic framework[36] encourages top management to achieve the following goals:

- Propel the company toward innovation as a multi-energy entity
- Ensure a reliable fuel supply to meet Chile's needs
- Foster competitive energy access
- Strengthen logistics infrastructure
- Address environmental challenges to create value for Chile

Key steps in its energy transition and enabling fuels plan include:

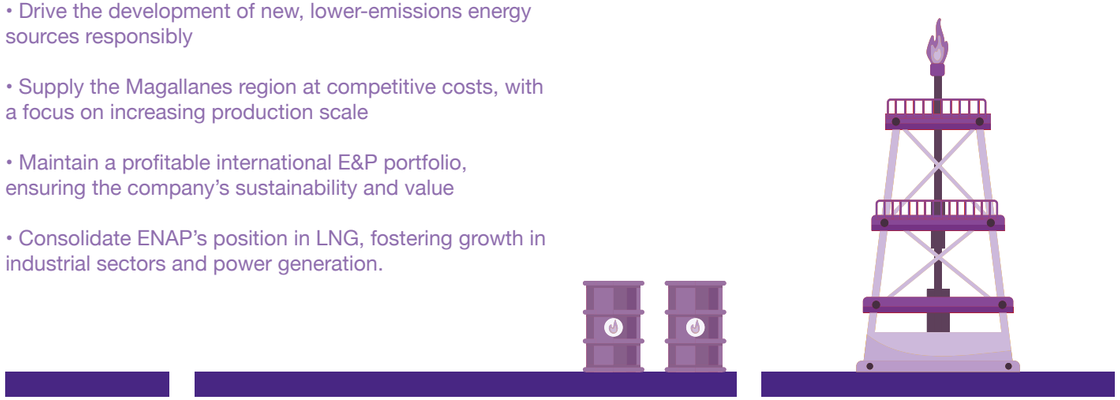
- Become a profitable multi-energy company
- Responsibly contribute to Chile's energy transition
- Provide Chile with reliable fuel supply
- Drive the development of new, lower-emissions energy sources responsibly
- Supply the Magallanes region at competitive costs, with a focus on increasing production scale
- Maintain a profitable international E&P portfolio, ensuring the company's sustainability and value
- Consolidate ENAP's position in LNG, fostering growth in industrial sectors and power generation.

Natural Gas as a Transition Fuel in Chile

ENAP has recognized natural gas as a pivotal low-emission fuel for the energy transition and developed expertise in the segment. With proven natural gas reserves in the Magallanes region and operations in O&G fields in Argentina, Ecuador, and Egypt, ENAP is also a shareholder in Innergy, a natural gas distribution company, and the Gasoducto del Pacífico interconnection pipeline (Argentina-Chile).[37]

As a strategic partner in Chile's GNL Quintero regasification terminal, ENAP has ventured into LNG retailing. It distributes the product to small industries to reduce emissions in remote central and southern Chile.

Under the energy transition banner, ENAP actively promotes the use of natural gas as a lower-impact alternative energy source. The company initiated a pilot project[38] with natural gas-powered long-distance trucks to efficiently replace diesel fleets. In so doing it set an example for other companies.



[36] https://www.enap.cl/la-empresa/marco-estrategico
[37] ENAP Reporte Integrado 2022
[38] ENAP Reporte Integrado 2022

Renewable Energy and Alternative Fuels

Beyond natural gas, ENAP focuses on emissions reduction through the development of renewable energy. It co-invests in power generation projects, and has established a geothermal power generation unit, Cerro Pabellon, in northern Chile and wind farms, known as Vientos Patagónicos, in the Magallanes region.

In collaboration with Chilean-Peruvian HIF Global, ENAP also participates in the Haru Oni project, a pilot initiative that produces e-gasolines and SAFs in Magallanes. The project involves prominent partners like Porsche, Enel Green Power, Siemens Energy, Gasco, and ExxonMobil. The e-fuels are being tested in various vehicles.

In December 2023, ENAP signed a Memorandum of Understanding (MOU) with HIF[39], aiming to make carbon-neutral fuels (e-fuels) viable in Chile. The agreement envisions the generation and commercialization of between 22.5 million and 37.5 million liters of e-gasoline from a future plant in Cabo Negro, Magallanes. These volumes represent a significant portion of the project's annual estimated production.

The agreement marks another milestone in ENAP's strategy to diversify fuel offerings and contribute to Chile's carbon neutrality goals. Meanwhile, ENAP is progressing with technical studies in its refineries to produce synthetic and renewable fuels from waste.

Synthetic fuels are produced with clean energy sources like wind. Green hydrogen is combined with recycled CO_2 to create carbon-neutral synthetic fuel. The proposed HIF Cabo Negro plant, which lies within the ENAP industrial site, is undergoing environmental evaluation. It features a 173,600 ton/year of e-methanol and 75 million liter/year of e-gasoline production capacity and requires a US$ 830 million investment. Renewable energy from the Faro del Sur wind farm will power the plant.

Carbon Capture, Utilization, and Storage and Evolving Decarbonization Technologies

ENAP is also exploring carbon capture from refineries to produce e-fuels. An MOU with Ferrostaal Chile and Ineratec[40] aims to analyze the feasibility of producing synthetic fuels. A 10MW hydrogen plant is under design as a pilot project. That plant will be able to produce 3,500 tons of e-gasolines per year by capturing CO_2 from existing facilities.

And ENAP is also championing the use of its facilities to establish a hub for exporting green hydrogen derivatives. An agreement with Total Eren, HIF Chile, FreePower Group, EDF, RWE, and HNH Energy is facilitating the transformation of the Gregorio port terminal in Magallanes.[41]

> "ENAP has clearly embraced the path toward a cleaner future by deploying sound and consistent actions and boosting private-public initiatives. Thus, Chile's NOC is an "early adopter seizing the moment."

[39] https://www.enap.cl/sala-de-prensa/enap-y-hif-global-firman-acuerdo-para-avanzar-en-uso-de-combustibles-sinteticos-en-chile
[40] https://www.enap.cl/sala-de-prensa/enap-avanza-en-la-produccion-de-nuevos-combustibles
[41] https://www.bnamericas.com/es/noticias/chilena-enap-y-firmas-internacionales-suscriben-acuerdo-logistico-de-hidrogeno-para-magallanes

Uruguay's ANCAP: A Strategy Emerges from the Need to Rethink the Value Proposition

Uruguay has become a global champion of sustainability over the last 20 years. The country has profoundly transformed its electric sector, to reach more than 90% renewable-based electricity production in less than 15 years (Ministerio de Industria, Energía y Minería Uruguay, 2023). The UK's Guardian, U.S. radio station NPR's Planet Money, the New York Times, Bloomberg, and countless industry journals have all featured this success and historic transformation.[42]

But in this process, the sectoral transformation focused on the state-owned electricity company, Administración Nacional de Usinas y Trasmisiones Eléctricas (UTE), as the executing arm of the public policy and—perhaps unintentionally—diminished the role of the national O&G company, Administración Nacional de Combustibles, Alcoholes y Portland (ANCAP).

Uruguay's first step in the energy transition was in many ways ahead of the curve for the region. It attracted a strong investment flow in the context of the country's legal certainty and economic stability, and Uruguay developed a model aimed at large-scale penetration of renewable energy with impressive results. But in meantime, ANCAP experienced significant internal and financial problems related to high dependence on imported oil, volatile international prices, and losing business units. These troubles forced an internal review of the group portfolio.

With the country's energy matrix in mind, Uruguay has defined a second transition that addresses the transformation of fossil fuel dependent, non-electrified consumption segments. This second transition is a fundamental part of the country's second NDC (Ministerio de Ambiente Uruguay, 2022), and part of its carbon neutrality ambitions for 2050. ANCAP's role in this second transition has been strengthened. It is set to become a leading piece of that transformation. But ANCAP does not have its own corporate Net Zero strategy or timeline.

ANCAP's corporate strategy review does not address formal strategic planning and the establishment of ESG practices as a mechanism for corporate reporting. Rather, it looks to emerging specific individual solutions that gradually build corporate sustainability. It is within this framework that energy transition management has been created to formalize these naturally emerging processes. ANCAP's energy transition management seeks to promote the development of low-carbon energy within the company. Such development is aligned with a responsible energy transition, defining green hydrogen and renewable energy development businesses under the company's traditional business arms, and maximizing the synergies between them (ANCAP, 2023).

While the company does not have a strategy, it does have emerging specific solutions that may gradually build corporate sustainability.

ANCAP's efforts aim to promote the development of energy resources in Uruguay through the following activities:

- Execute contracts for feasibility evaluation and potential production of hydrogen and/or its derivatives from renewable energies generated in offshore Eastern Republic of Uruguay with leading energy sector companies.

- Reactivate hydrocarbons exploration activity in the entire offshore area with private energy companies shouldering the cost and risk through the signing of contracts for the offshore areas that have already received offers. This arrangement allows for significant investment and business participation.

- Generate knowledge to produce sustainable fuels and biofuels and execute other projects or operations related to the energy transition, e.g., underground storage of CO2 (and other fluids).

The Ministry of Industry, Energy, and Mining (MIEM) defines Uruguay's energy policy, and, consequently, the second transition's various components, including hydrogen production, synthetic fuels, and sustainable mobility. ANCAP is Uruguay's autonomous entity with the experience and local capabilities to implement a significant portion of those energy policies in coordination with private partners.

Therefore, ANCAP must officially establish that it is following the path of some leading global oil companies, and gradually transform itself into an energy company.

[42] https://www.theguardian.com/global-development/2023/dec/27/uruguays-green-power-revolution-rapid-shift-to-wind-shows-the-world-how-its-done
https://www.npr.org/transcripts/1211922036
https://www.nytimes.com/2022/10/05/magazine/uruguay-renewable-energy.html
https://www.bloomberg.com/news/articles/2023-08-02/green-hydrogen-will-further-uruguay-s-role-as-renewables-leader

Advances in Offshore Wind, Hydrogen, and Synthetic Fuels as Part of the New Value Proposition

Uruguay's hydrogen strategy, formalized by the 2023 Green Hydrogen Roadmap (Ministerio de Industria, Energía y Minería Uruguay, 2023), incorporates several approaches and possibilities for producing hydrogen and its derivatives. Hydrogen production is based on renewable electricity installed onshore (solar and wind) that integrates the participation of existing market agents and new actors who would incorporate new capacity. Offshore wind generation capacity is also considered as a hydrogen production alternative, which is consistent with ANCAP actions aimed at applying a model of rounds for the exploitation of wind power on the country's maritime platform. ANCAP will lead those rounds and their management on behalf of the Uruguayan state.

ALUR, an ANCAP subsidiary, is dedicated to sustainable agribusiness through the production of biodiesel, bioethanol, chemicals, energy, and sugar. ANCAP's plans address e-fuel production based on the availability of captured biogenic CO2 from ALUR operations (ANCAP, 2023).

In December 2022, ANCAP launched a Request for Expression of Interest for e-Fuels Project Developers.

After a competitive bidding process, Chilean-Peruvian HIF Global was selected in June 2023 to implement the project, which is located in Paysandú, on Argentina's border. The project aims to produce 180,000 tons of e-gasoline per year by capturing 710,000 tons of CO2 from the combustion of biomass and distillation of alcohol from biomass, and producing 100,000 tons of green hydrogen. The project will include a 1 GW alkaline electrolyzer and the installation of 2 GW of additional renewable electricity generation from photovoltaic and wind sources. Total investment will add up to US$1.985 billion for CO2 capture, methanol production, and synthetic gasoline completion, and another US$ 2 billion for the installation of wind and solar power generation and transmission lines.

In addition, ANCAP is considering a specific project for the installation of a hydrotreated vegetable oil (HVO) unit to produce green diesel or SAFs for export and the domestic market.

The Ambition to Transform from Small NOC to Sustainable NEC

ANCAP stands as one of the pioneering NOCs in the LAC region. It has explored multiple business models aimed at sustainability and a gradual decarbonization of its operations. This transition is also the natural path for the state-owned company, given the characteristics of its operations (i.e., a deep dependence on imported crude oil) and that it must also respond to the climate ambitions of one of the top countries in the region in terms of sustainability.

But ANCAP must still set specific goals for decarbonizing its operations and define control and monitoring mechanisms for its progress under ESG methodologies and protocols. Even though the company is moving rapidly in terms of offshore wind, hydrogen, and orientation toward e-fuels, it has yet to match Ecopetrol's level of formalizing these sustainable components as part of its new value proposition.

Other NOCs have created their own renewable energy portfolio and developed internal projects aimed at decarbonizing their O&G operations to meet established emissions reduction or Net Zero goals. As of this writing, ANCAP has not begun this type of investment with its own sustainable assets to incorporate them into a vision of transforming into an energy company.

And although there is an opportunity for early decarbonization through using less carbon-intensive fuels, ANCAP has yet to incorporate such a possibility into its corporate strategy to encourage the replacement of liquid fuels with natural gas and achieve the associated decline in emissions.

Developing a Strategy to Seize the Moment

This category can perhaps be best understood by way of the famous glass-half-full maxim. Our analysis notes efforts and some results toward decarbonization and climate action, but these actions have been uneven over time, particularly with respect to SDG implementation and the Paris Agreement, as well as sustained investments in energy transition strategies or technological developments.

The NOCs in this category are:

- Petrobras (Brazil)
- YPF (Argentina)

To be fair, given the major economic and political headwinds that Brazil and Argentina have faced over the last several years, their NOCs have been in no position to sufficiently advance or develop strategic imperatives consistent with SDG and Paris Agreement commitments. That dynamic has begun to change over the last 12-18 months, as evidenced by Petrobras's strategic plan, which was released in late 2023. In Argentina, the political and economic turmoil appears to be yielding to a "new status quo" that in turn will allow YPF to revise its role.

Brazil's Petrobras: The Enormous Challenge of Leading a Country's Decarbonization

Local debate and the global climate discussion necessarily demand that nations' development opportunities be considered. But environmental sustainability has historically conflicted with economic development, particularly where extractive industries are involved. Brazil has been no stranger to this dichotomy. In that context, it will soon lead much of the global discussion on the subject as it hosts the G20 in 2024 and COP30 in 2025.

Prior to COP28, Brazil confirmed its commitment to reducing its GHG emissions by 37% from 2005 levels by 2025. This affirmation is included in its updated NDC. The country has also committed to reducing its emissions 50% from 2005 levels by 2030. Its commitments include a long-term goal to achieve climate neutrality by 2050.

Brazil's updated NDC is broad in scope. It considers the means of implementation for mitigation and adaptation actions across all economic sectors. Current government rhetoric leans heavily toward strengthening Brazil's environmental position. That kind of thinking is crucial, as Brazil's emissions and climate action concerns pertain far more to its non-energy sources than do other LAC countries' interests.

Meanwhile, according to the Brazilian Oil and Gas Institute, 2023 data indicate that Brazil is the ninth largest oil producer in the world and the largest in the LAC region. It has quickly surpassed traditional producers like Venezuela and Mexico. Its success is directly related to the pre-salt reserves in its offshore deepwater plays. Petrobras is immersed in the need to align the incredible momentum of its O&G production, which presents clear opportunity for the monetization of Brazil's fossil reserves, with the need to effectively execute the country's environmental commitments. This balancing act will be the company's main challenge in the short and medium term.

Brazil has also been a global leader in biofuels (IEA, 2021), with Petrobras as the executing arm. This role gives the company the credentials to act as a leader in decarbonization. As part of an internal restructuring to address the energy transition, Petrobras created the Executive Directorate of Energy Transition and Sustainability in early 2023 to coordinate decarbonization, climate change, new technologies, and sustainability activities. The directorate also coordinates commercial natural gas activities. Petrobras has declared that it must intensify the decarbonization of its operations, knowing that O&G production will also be a must to guarantee Brazil's energy security (and that of the world) over the long term (Petrobras, 2024).

Thus, the company is taking on the challenge of replenishing reserves and producing oil, while reducing GHG emissions and developing more sustainable products.

In 2021, Petrobras assumed the goal of bringing its operational GHG emissions to Net Zero within a period compatible with the Paris Agreement. It also intends to influence its partners to achieve the same goal for non-operated assets.

Petrobras has committed US$ 3.7 billion to decarbonizing its operations by 2027. It claims to have achieved a 39% reduction in its operations' CO2 emissions between 2015 and 2022, with its emissions factor per barrel 70% lower than the industry average (Petrobras, 2024).

The company has made six corporate commitments related to the reduction of GHG emissions to mitigate climate change:

Reduce absolute operational emissions
- The emissions reduction goal encompasses 100% of assets operated in all Petrobras businesses, including power generation, for all GHGs. The goal to cut absolute operational emissions 30% from 2015 levels by 2030 is consistent with the progressive reduction the company has implemented over the last decade.

Decrease GHG intensity in the E&P segment
- Petrobras will seek to continue to improve the carbon efficiency of E&P activities, with the goal of reaching 15 kg CO2 e/boe in 2025, to be maintained until 2030.

Decrease GHG intensity in the refining segment
- Petrobras will seek to reduce the intensity of refining GHG emissions by 16% by 2025 (target of 36 kg CO2 e/CWT), and then by 30% by 2030 (target of 30 kg CO2 e/CWT).

Zero routine flaring
- In 2018, Petrobras endorsed its support of the World Bank's Zero Routine Flaring by 2030 initiative. Fulfillment of that initiative's criteria is one of the company's sustainability commitments. In 2021, Petrobras used 97.2% of gas produced.

Less emissions, more methane efficiency
- Petrobras climate commitments seek a 55% reduction in the intensity of upstream segment methane emissions from 2015 levels by 2025.

CO2 reinjection
- Petrobras is committed to achieving an 80 million tons of CO2 cumulative total reinjection by 2025, which will contribute to technological evolution and cost reduction, and demonstrate the safety of CCUS technology for the O&G industry and other sectors. Petrobras has one of the largest offshore CO2 reinjection programs in the LAC region, which has allowed the company to increase production efficiency while reducing emissions per barrel. In 2022 Petrobras broke the world record by reinjecting 10.6 million tons of CO2 into pre-salt reservoirs. That amount was equivalent to 25% of the industry's total globally reinjected volumes that year.

Moving from Planning to Action

Petrobras's 2024-2028 strategic plan considers more than US$ 100 billion in investments. The strategic plan looks to increase investment in the energy transition and allocates 9% of its budget to low-emissions energy like wind, solar, and natural gas.

Petrobras is progressing on its actions toward decarbonization, as follows (Petrobras, 2024):

- **Oil produced with high carbon efficiency.** E&P investments have focused on pre-salt fields, given their prolific nature and increased operational efficiencies. The barrels are considered to be some of the lowest carbon intensity in the world at around "10 kg of CO2 per barrel of oil produced, against the global average of 26 kg/bbl."[43]

- **Adaptation of the refining park with the Biorefino Program.** The program includes projects to produce a new generation of more modern, sustainable fuels, using renewable or residual raw materials.

- **Recovery or conservation of 3% of national forests and natural areas.** Petrobras supports biomass projects in the Atlantic Forest, Amazonia, Caatinga, and Cerrado through its Socio-Environmental Program. Thus, the company actively participates in mitigating GHG emissions caused by deforestation.

- **Research and development (R&D).** Technologies that contribute to achieving established decarbonization objectives are developed and evaluated, focusing on the advanced biofuels segment and renewable energies.

- **Offshore wind and green hydrogen.** Petrobras will have the largest offshore wind power generation potential in Brazil in terms of capacity. The company's interest in its own developing projects, in addition to projects it is partnering on with other companies (e.g., Equinor), adds up to a potential 23GW. Offshore wind will be oriented to green hydrogen production and derivatives.

Steps of a Giant

Petrobras has taken the early steps toward positioning itself as a leader in energy transition activities. It still lags behind other regional NOCs, but its ambitious goals and leading role in influencing climate goal compliance could give Brazil an unprecedented boost toward decarbonization. The company's participation in R&D and the permanent development of a proprietary technological package places it ahead of other large global companies undertaking their own efforts. And the ambitious proposal to increase participation in the transition by identifying new business spaces and greater efficiencies in its traditional operations comes with a strategic planning process that is integrated into Brazil's energy planning. This arrangement helps to establish clear goals and budget planning that corresponds to compliance.

In addition, Brazil's assets have historically been deeply synergistic with emerging technologies. The history of biofuel development and the technological package that, based on biofuels and hydrogen, can potentially be integrated into new value propositions represents a great opportunity for Petrobras.

Petrobras's big challenge will be to make the rapid, profitable monetization of Brazil's natural resources compatible with contributing to a substantial improvement in social well-being as Brazil continues to develop. At the same time, it must take advantage of its momentum to promote decarbonization in the Brazilian market and strengthen an increasingly sustainable company portfolio.

Those factors are why Petrobras can assume regional leadership in the short term for sustainability and an integrative energy transition model for NOC operations.

[43]Brazil pursuing all options to safeguard long-term energy supplies, Offshore Magazine, Aug 1 2022 https://www.offshore-mag.com/home/article/14279064/brazil-pursuing-all-options-to-safeguard-longterm-energy-supplies

Argentina's YPF: The First NOC

YPF plans to fully decarbonize its operations by 2050. It presents its intermediate milestones in its 2022 Sustainability Report (Reporte de Sustentabilidad). In 2018, YPF's president led the B20 energy chapter at the annual G20 meeting in Argentina. Subsequent changes in YPF's top management modified the company's short-term actions and focus, but left long-term objectives untouched. The company's 2022 Sustainability Report revamped the Climate Change Roadmap, which includes short and medium-term objectives for decarbonizing the O&G business and promoting renewable and other energy solutions.

YPF's energy strategy is consistent with Paris Agreement goals and NDCs to achieve carbon neutrality by 2050. The strategy also aligns with the role that the Argentine government (as of 2023) had assigned the company as a driver of the Argentine and regional economy. Its goals are broken down into annual intermediate objectives that are part of the 2023-2027 business plan. These goals are monitored regularly. They are integrated into company employees' performance evaluations, including those of the executive vice presidents and the CEO, and impact the variable compensation bonus. YPF has committed to investing in the decarbonization of the current and future energy system. To achieve its goals, it has developed a set of short and medium-term aspirations.

> YPF is deepening the path to low-carbon energy production. During 2022, it cut emissions 7%, from 15.6 to 14.5 million tCO2e, while increasing production, thus achieving its objectives.

Since 2021, YPF has had a clear, pragmatic strategy based on current strongholds to redeploy capital into new activities that will lead the energy transition. This strategy is based on three key timeframes:[45]

• **2023 – 2035:** Monetize crude oil, focusing on Vaca Muerta and conventionals production. YPF commits to reducing GHG emissions per barrel produced during this phase.

• **2027 – 2050:** Monetize natural gas and LNG. YPF will capitalize on Argentina's natural gas proven reserves, emphasizing the role of natural gas in the country's strategy. The company is also developing an LNG liquefaction terminal in Bahia Blanca to export up to 10 MTPA.

• **2030 – 2050:** Green hydrogen, lithium, and other clean energies. YPF has established a dedicated department, "New Energies," to spearhead projects on lithium and hydrogen. YPF Luz, a subsidiary, consolidates the power generation business and stood as the second-largest renewable energy producer in the country in 2023. The company continues to inaugurate wind and solar power generation plants annually.

This strategy is then divided into short-, mid- and long-term activities, as Figure 15 illustrates:[46]

YPF Short, Mid and Long-term Energy Transition Activities

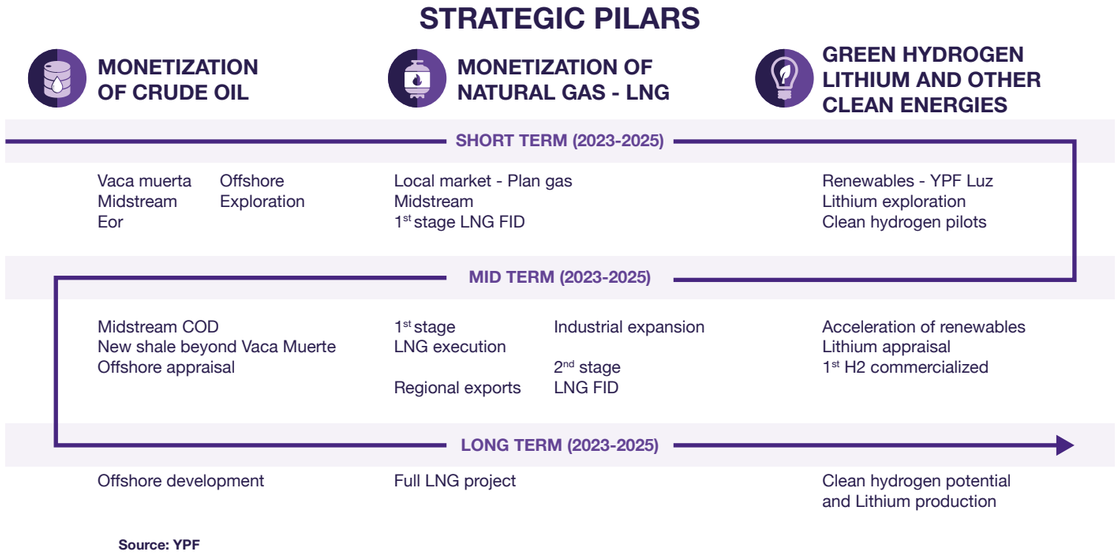
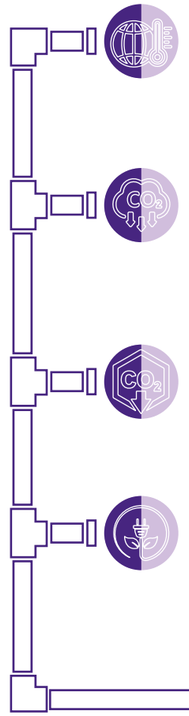


Figure 18

[45]YPF DAY - STRATEGIC OUTLOOK - MARCH 10TH, 2023
[46]YPF DAY - STRATEGIC OUTLOOK - MARCH 10TH, 2023

Climate Change Roadmap

To further advance its goals, YPF has also created a Climate Change Roadmap,[47] which addresses four main topics:



• **Adaptation and Climate Change Risk Management:** Map, manage, and mitigate transition and physical risks for facilities and operations against extreme weather events

• **Low-carbon O&G Operations:** Prioritize energy efficiency to reduce direct emissions, integrate renewable energies, minimize routine flaring, and reduce methane emissions (leaks and venting)

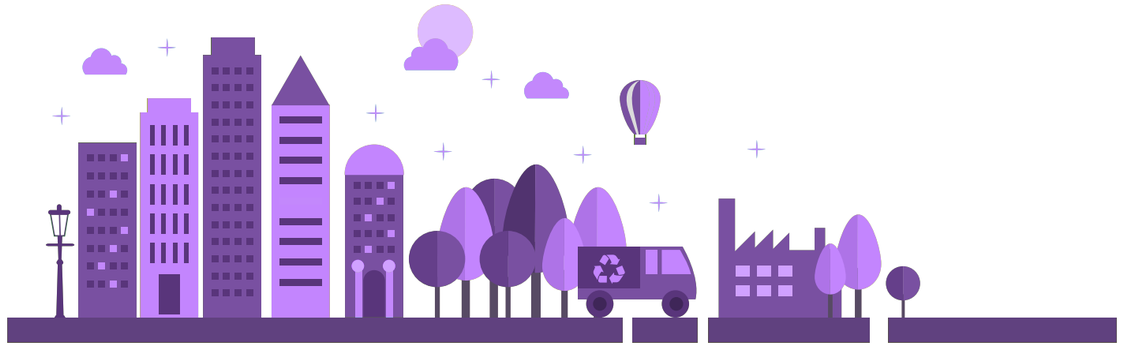
• **Low-carbon Solutions and Offsetting:** Develop new energy solutions, offer lower-carbon products, and engage in offset projects, including nature-based solutions (NBS)

• **Electricity and Renewables:** Ensure profitable growth in electricity and renewables, with YPF Luz leading the charge.

Investing in Technology

To boost R&D in the O&G sector, YPF has forged a joint venture with the government agency, National Scientific and Technical Research Council (Consejo Nacional de Investigación en Ciencia y Tecnología, or CONICET), called Y-TEC. The venture seeks to increase O&G production, primarily in upstream unconventionals, and promote environmental sustainability through decarbonization, CCUS, reduction of fuels' sulfur content, resolution of environmental situations, efficient gas transport, and sustainable agriculture.

YPF is also actively exploring green and blue hydrogen production projects. In the case of green hydrogen, YPF plans to leverage southern Argentina's YPF Luz renewable energy capacity. The company is analyzing various blue hydrogen projects to address current refinery CO2 emissions.



[47]YPF Reporte Sustentabilidad 2022

Incomplete at the Moment

These companies may show a lack of coherent, strategic focus associated with climate action and SDGs. Alternatively, their role may be severely underdeveloped or in the early development stage, and possibly constrained by a combination of budget, resources, politics, and/or international sanctions.

The NOCs we place in this category are:

- PDVSA (Venezuela)
- PEMEX (Mexico)
- YPFB (Bolivia)

Venezuela's PDVSA: Isolated and Adrift

For several years, PDVSA has suffered from Venezuela's greater economic and humanitarian disaster and the targeted sanctions regime that several western governments have enforced. The NOC has been forced to navigate international isolation as sanctions have broadened over time. In this context, environmental standards, sustainability, and climate action have become impossible.

Caracas-based human rights NGO, Provea, states that between 2010 and 2016, PDVSA was responsible for more than 46,000 crude oil spills.[48] Exact data after 2016 is not available—PDVSA stopped releasing data that year. Residents and local environmental groups have spoken out against the spills and oil that washes up on the beaches of Lake Maracaibo, as well as the evidence of biodiversity and marine life degradation due to PDVSA drilling.[49]

From operational and safety issues to out-of-control venting and flaring (approximately 2.7 billion cubic feet of natural gas every day; Venezuela is sixth in the world for natural gas flaring)[50], PDVSA activities run contrary to climate goals. The NOC exists in survival mode with little-to-no strategic planning to incorporate evolving industry trends and best practices, particularly those related to ESG, nor any references to decarbonization goals.

> At the height of sanctions, and across a series of COP meetings, Venezuela committed very little: It offered no Net Zero target, no deforestation reduction. Venezuela did not sign the global methane pledge. This status remains unchanged, even after sanctions have been eased and the COP28 meeting has closed. There is no sign of revised strategic planning focused on decarbonization and Net Zero goals.

[48] https://provea.org/actualidad/en-seis-anos-pdvsa-derramo-856-72285-barriles-de-petroleo-al-medio-ambiente/

[49] Paúl, María Luisa. "Oil slicks and algae blooms marring Venezuela's largest lake are visible from space" The Washington Post. October 7, 2021. NASA satellite photos show oil spill, pollution in Venezuela's Lake Maracaibo - The Washington Post

[50] Voght, David and Martin, Jeremy M. "Venezuela sanctions and climate action — a fresh approach." The Hill. December 3, 2021. https://thehill.com/opinion/energy-environment/584243-venezuela-sanctions-and-climate-action-a-fresh-approach/

Post Sanctions

The Venezuelan government has sought to dedicate swaths of land to ecological conservation, which PDVSA indicates is part of its commitment to the environment. But there is almost no indication that PDVSA plans to improve, or is in the process of improving, production methods.

Since sanctions were relaxed in late 2023 as part of the Barbados Agreement,[51] renewed collaboration between PDVSA and the international O&G industry has led to positive production trends, even as the firm copes with years of underinvestment and deterioration.[52] There are also indications that renewed operations of certain joint ventures (JVs) between PDVSA and international companies like Chevron and Repsol will lead to the incorporation of ESG and sustainability practices as the partner firms assume **"more governance and operational control."**[53]

Reuters reports that, according to late-2023 OPEC data, Venezuela's crude output averaged 794 kb/d through November, an increase from the 716 kb/d of 2022 and the 636 kb/d of 2021. It remains unclear how the industry's restart and renewal will incorporate sustainability and decarbonization goals.

There is nothing indicating that PDVSA plans to incorporate sustainable practices into its E&P activities, nor does it appear that the company will explore any type of alternative fuels or fuel sources. Netherlands-based investigation and research group, Sustainalytics, ranks PDVSA's ESG commitments the lowest of major companies; other aspects of is production efforts also place it in the lower rankings, including a high number of work accidents.[54]

PDVSA struggles with transparency. It has not made production data outside of oil production itself available for years. With the easing of sanctions also pertaining to financial markets and bonds and debt associated with the firm, there may be adjustments that address global best practices. But as of this writing, there are no formal strategies or plans under development or implemented.

[51] Daniels, Joe and Smith, Jamie. "US eases sanctions on Venezuela following election deal." Financial Times. October 19, 2023. https://www.ft.com/content/32145f15-3eb0-4b91-b0b5-5e3951e336bc

[52] Spetalnick, Matt; Parraga, Mariannna. "US broadly eases Venezuela oil sanctions after election deal" Reuters. Octover 19, 2023. US broadly eases Venezuela oil sanctions after election deal | Reuters

[53] Buitrago, Daisy. "Venezuela's PDVSA, Spain's Repsol agree to expand oil joint venture." Reuters. December 18, 2023. https://www.reuters.com/markets/commodities/venezuelas-pdvsa-spains-repsol-agree-revive-oil-joint-venture-2023-12-18/

[54] Petróleos de Venezuela SA ESG Risk Rating (sustainalytics.com)

Mexico's Pemex: Debt and Deliberation

Pemex's dire financial context is no longer novel, but still important. For several years, the NOC has been the most indebted oil company in the world, with around US$ 100 billion in debt—**about 8% of Mexico's GDP, according to The Economist.**[55]

In 2023, Fitch Ratings downgraded Pemex's Long-Term Foreign and Local Currency Issuer Default Ratings (IDRs) to B+ from BB-. Fitch Ratings states that the downgrade reflects Pemex's continued weak operating performance, which further limits its ability to source financing from banks, investors, and suppliers. Fitch Ratings also lowered the company's ESG Relevance Score to '5'[56] to reflect **"the environmental and social impact associated with multiple accidents at Pemex's operating facilities since February 2023, which resulted in casualties and injuries to its employees and damages to critical infrastructure and assets."**[57] The Economist indicates that during the Andres Manuel Lopez Obrador administration, the government has injected over US$ 73 billion into the company.[58]

Debt levels, and government transfers to sustain the firm, are relevant as they have occurred despite the lack of a dedicated office or department focused on sustainability goals, a decarbonization plan, or energy transition objectives. The upside of the company's financial duress is that it has given bond holders and institutional investors focused on ESG room to pressure Pemex, and under that pressure, the company created a sustainability committee at the board level in May 2023. This committee, composed of members from Pemex's Administrative Council, including executive officers and high-ranking government representatives, has been tasked with aligning the state-owned company with ESG goals. Those goals are unclear, however. For example, Pemex has yet to issue bonds that are specifically tied to green projects.

Sustainability Plan Announced, but No Firm Net Zero Plan

Until March 2024, Pemex had made no formal commitment to attaining Net Zero. Moreover, there was no Net Zero road map in the company's strategic or corporate planning.[59] In its 2023-2027 business plan, Pemex acknowledges the impact that the energy transition is having on its operations. But although it recognizes the need to address environmental concerns and make commitments to implement more sustainable practices, it sees the O&G industry as having a long-term optimistic outlook.

Pemex's deliberate posture on Net Zero and ESG is evident through its emissions profile, particularly that derived from flaring. Pemex has not reduced its flaring-to-production ratio or its emissions-to-production ratio. It made progress from 2015-2017, but those ratios have since returned to 2015 levels.

Mexico's state-owned utility, Comisión Federal de Electricidad (CFE), is responsible for increasing installed capacity. National laws and regulations for Pemex define the company as a decentralized agency whose main function is to execute exploration, exploitation, and other actions demanded by the operation and strategic management of the oil and gas industry.

[55]Pemex is the world's most indebted oil company, The Economist, October 12, 2023 https://www.economist.com/the-americas/2023/10/12/pemex-is-the-worlds-most-indebted-oil-company

[56]The Fitch Ratings ESG relevance score aims to "articulate the level of influence an environmental, social or governance issue has had on a credit rating decision." Scores range from '5' to '1', with a higher score indicating greater relevance. A relevance score of '5' indicates an ESG risk factor that on a standalone basis has a direct impact on the rating.

[57]https://www.fitchratings.com/research/corporate-finance/fitch-downgrades-pemex-idrs-to-b-on-rating-watch-negative-14-07-2023

[58]Pemex is the world's most indebted oil company, The Economist, October 12, 2023 https://www.economist.com/the-americas/2023/10/12/pemex-is-the-worlds-most-indebted-oil-company

[59]https://www.pemex.com/acerca/plan-de-negocios/Documents/business_plan_2023-2027.pdf

Ambitions for 2050

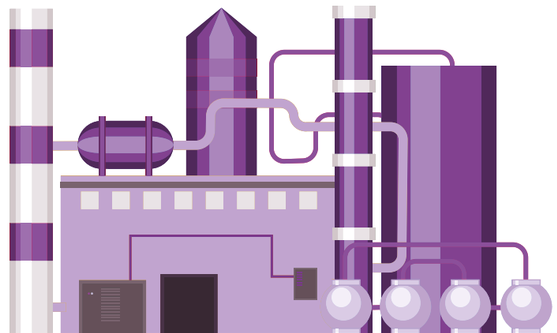
Pemex formally launched its Sustainability Plan in mid-March 2024, after much of this assessment and writing was complete. The company hosted a presentation and virtual launch event on March 25 that included representatives from S&P Global Commodity Insights, who Pemex had retained to advise and support the plan's development.[60]

As the world's most indebted company, the Mexican NOC finds it increasingly difficult to secure financing. The company's lack of commitment to ESG and overall strategic planning to reduce emissions negatively impacts that position. During the launch event, Pemex executives discussed how the new plan should allow for improved access to capital and at better terms.[61]

Pemex's Sustainability Plan appears to be a marked improvement. But the question-and-answer session during the virtual presentation revealed significant uncertainty over its implementation and how the NOC will secure the financing to make the level of investments that the plan and proposed strategy require. This lack of certainty seems even more pronounced in the medium and long term.

Moreover, the proposed GHG emissions reduction goals around methane emissions and gas flaring, which include a 30% reduction in methane emissions and zero routine gas flaring by 2030 (Figure 19), are questionable. Existing analysis, particularly across the course of the current government's management at the firm, place such a goal far out of reach. To wit, only days before the virtual presentation of the Sustainability Plan, Reuters published an investigative article that noted **"Pemex put off urgent repairs and maintenance at an important offshore platform for months, resulting in methane spewing into the atmosphere."**[62]

> But perhaps even more importantly, as Figure 19 reflects, the plan only calls for "Ambition to 2050" for Scope 1 and 2 GHG emissions. It is not a formal commitment, objective, or firm strategy. This position places the company far behind its peers when it comes to Net Zero efforts.



[60]PEMEX Sustainability Plan, March 2024. https://www.pemex.com/acerca/plan-de-sostenibilidad/Documents/plan_sostenibilidad_pemex.pdf

[61]"Mexico's Pemex bids for more favorable financing rates with sustainability plan." March 25, 2024. Reuters. https://www.reuters.com/business/energy/mexicos-pemex-bids-more-favorable-financing-rates-with-sustainability-plan-2024-03-25/

[62]Eschenbacher, Stefanie and Martell, Allison. "Mexico's Pemex put off repairs despite vast methane leak" Reuters. March 22, 2014. https://www.reuters.com/business/environment/mexicos-pemex-put-off-repairs-despite-vast-methane-leaks-documents-sources-2024-03-22/

Sustainability Strategic Pillars — Sustainability Plan of Petróleos Mexicanos

GHG emission reduction additional goals and ambitions

Additional goals

- From 2024, achieve at least a **gas utilization level of 98% in E&P**
- By 2030, achieve a **30% reduction in methane emissions** (compared to base year 2020)
- **Zero routine gas flaring in E&P** by 2030

Ambition to 2050

- **Net-zero scope 1 and 2 GHG emissions**

Source: PEMEX • Figure 19

Bolivia's YPFB: Whither Natural Gas and Alternative Fuels

YPFB has not stated a plan for a transition to Net Zero carbon emissions, investments in renewables, or carbon capture and sequestration. But there are continued developments around its core natural gas business and growth in investment and focus on other opportunities like urea and ammonia plants and biofuels to reduce Bolivia's fossil fuel use.[63]

Given its base of operations, YPFB could move out of its "Currently Incomplete" classification. This potential is based largely on the company's ability to consistently profit at a large margin (roughly US$ 2 billion since 2018).[64] An efficient, profitable organization is a must for pursuing ESG objectives.

Yet, the need to formulate and implement a strategic plan that encapsulates Net Zero and decarbonization objectives (other than biofuels) remains. Bolivia did not join the global methane pledge that was first launched in Glasgow. Many new signatories were added in Dubai at COP28.[65]

> Bolivia was not among them. This apparent reticence presents a major area for policy-making improvements, not just for YPFB, but also for the country.

[63] https://www.ypfb.gob.bo/es/urea#planta

[64] 2018 data from Statista: Sales revenue generated by Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) from 2015 to 2018. Dec 20, 2023. Revenue of oil & gas company YPFB in Bolivia | Statista 2022 statement from MarcoPress: Bolivia's YPFB eyes oil income of US $ 1,900 million for this year. April 26, 2021. Bolivia's YPFB eyes oil income of US $ 1,900 million for this year — MercoPress Full financial breakdown can be found at: Presentación (ypfb.gob.bo)

[65] https://www.globalmethanepledge.org/

Natural Gas Concerns and Involuntary Energy Transition

Much of YPFB's increasing profitability has come from its core natural gas business, specifically exports, largely to Brazil and Argentina (see more on these countries in their pertinent sections and case studies earlier in this document). **Those two countries represent more than 70% of YPFB sales.**[66] Official data show that sales reached US$ 2.4 billion in 2021.[67]

Ironically, internal and domestic demand has grown while overall production has declined. Several independent observers and consulting firms have highlighted these trends and their impact on the company for the coming years.[68] Some estimates point to a supply-demand imbalance as soon as 2030, with a potential disruption in natural gas exports to Argentina and Brazil starting in 2024.[69] The corresponding economic impact for Bolivia and, of course, YPFB will also come into play.

Much of the problem comes from low-efficiency plants that operate under a subsidized US$ 1.5/mmbtu for natural gas. This arrangement has driven Bolivia's domestic natural gas demand upward. If the dynamic continues, it will further impact YPFB's profitability. For now, the company must rely on a series of necessary structural reforms to motivate a review of the traditional business model.

These domestic trends, along with developments in the key neighboring markets of Brazil for LNG import capacity, and Argentina with its surging Vaca Muerta production, are significant. A Bolivian Center for Documentation and Research (CEDIB) researcher described these shifts as **"forcing the country into an 'involuntary' energy transition."**[70] But several factors could make the **"involuntary"** energy transition quite painful and an example of the vicious cycle concept, as they reinforce the detrimental outcome.

For YPFB, efforts to move beyond the status quo have begun to take shape in the form of investment in and development of biofuels. But it may also need to undertake some strategic planning focused on investing in and deploying more renewable energy and technology.

YPFB has made major strides toward completing its first renewable biodiesel plant. A second is due for completion at the end of 2024.[71] The completion of **"Plant 1"** will provide Bolivia with a consistent supply of renewable biodiesel fuel, which will be derived from locally and regionally sourced organic material as well as used cooking oil.

YPFB has stated through its external publications that it recognizes its responsibility to the environment and factors like the SLO. It is transparent in terms of audits and financial presentations, unlike many of its cohort. It could set Net Zero plans and redirect funds to further invest in projects to lower emissions. The ability to redirect investments may become more challenging; it will demand attention if YPFB wants to move closer to some of its more successful NOC peers.

[66] https://www.woodmac.com/press-releases/bolivian-gas-production-to-decline-faster-than-expected-exports-to-brazil-and-argentina-to-cease-by-20303/

[67] https://dialogochino.net/en/climate-energy/53587-bolivia-energy-transition-gas-depleted-involuntary/

[68] https://www.argusmedia.com/en/news/2492732-falling-bolivia-gas-supply-challenges-brazil

[69] https://www.woodmac.com/press-releases/bolivian-gas-production-to-decline-faster-than-expected-exports-to-brazil-and-argentina-to-cease-by-20303/

[70] Cespedes, Rocio Lloret. "With its gas in decline, Bolivia faces an involuntary energy transition." Dialogo Chino. May 5, 2022. https://dialogochino.net/en/climate-energy/53587-bolivia-energy-transition-gas-depleted-involuntary/

[71] Kotrba, Ron. "Bolivian officials supervise final construction phase of state-owned biodiesel plant" January 10, 2024. Biobased Diesel Daily. Bolivian officials supervise final construction phase of state-owned biodiesel plant (biobased-diesel.com)

Workforce and Infrastructure Readiness

In 2022, the Institute of the Americas (IOA) conducted a multifaceted research project aimed at assessing the concept of energy transition, the policy and regulatory environment pertaining to the energy transition, and, most importantly, the state of workforce readiness across eight LAC countries (Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay).

The resulting Latin America Energy Transition Workforce Readiness Assessment and Barometer webpage on the IOA website includes a final report, the barometer, energy transition snapshots, and a variety of resources.[72]

That analysis and research was used to form the basis of the following section in this paper. The overall assessment and recommendations have been slightly updated to reflect developments in the time since the information was first published. Most notably, and a new section in this report, is the role and impact of artificial intelligence (AI) and its relevance for the LAC energy workforce. This issue was not part of the original research effort.

The energy transition presents the LAC region with an opportunity to foster high-quality job creation, economic diversification, and energy security while tackling energy poverty. Hence, a pivotal aspect of the energy transition entails upskilling human capital and ensuring workforce readiness.

In many respects, the energy transition can be conceptualized and centered on three pillars: decarbonization, decentralization, and democratization. Decarbonization involves developing low carbon and/or Net Zero full cycle energy sources. Decentralization pertains to flexible economic solutions tailored to the region's diverse energy sources and requirements. Finally, democratization underscores the need to implement community-driven energy solutions aimed at reducing regional energy disparities.

Throughout the LAC region, nations have long grappled with challenges related to fostering sustained economic development and job creation. Understanding the energy transition as both a policy imperative and overarching economic framework for governments, private sectors, and academia is crucial. Such comprehension can shed light on potential employment prospects linked to the energy transition and gauge the region's readiness to seize them.

[72] https://iamericas.org/energytransitionreport/

The Role of Artificial Intelligence

AI is significantly impacting workforce readiness in the LAC energy sector by revolutionizing various aspects of operations, management, and skill requirements. For this discussion, there are five broad themes:

• **Automation and Efficiency:** AI-powered automation is streamlining routine tasks in energy production, distribution, and management. This effort enables companies to optimize their operations, reduce downtime, and improve overall efficiency. As a result, workers must adapt to new roles that involve overseeing AI systems, analyzing data insights, and making strategic decisions based on AI-generated recommendations.

• **Predictive Maintenance:** AI algorithms can analyze vast amounts of data from sensors and equipment to predict maintenance needs accurately. By implementing predictive maintenance systems, LAC energy companies can minimize equipment failures, extend asset lifespan, and optimize maintenance schedules. Workers must be trained in data analytics and interpretation to effectively utilize these AI-driven maintenance systems.

• **Smart Grid Management:** AI plays a crucial role in managing smart grids, which are becoming increasingly prevalent in the LAC energy infrastructure. AI algorithms can analyze real-time data from smart meters, renewable energy sources, and consumer behavior to optimize energy distribution, reduce wastage, and balance supply and demand. Workers must be equipped with skills in AI, data analytics, and grid management to operate and maintain these smart grid systems.

• **Energy Forecasting and Planning:** AI-powered predictive analytics are enhancing energy forecasting and planning capabilities in the LAC energy sector. By analyzing historical data, weather patterns, market trends, and consumer behavior, AI algorithms can generate accurate forecasts of energy demand and supply. This information enables energy companies to optimize resource allocation, plan infrastructure investments, and anticipate future energy needs. Workers must possess skills in data analysis, statistical modeling, and energy economics to leverage these AI-driven forecasting tools effectively.

• **Skills Enhancement and Training:** AI technologies are being used to develop innovative training solutions for the workforce in LAC's energy sector. Virtual reality (VR), augmented reality (AR), and AI-driven simulations can provide hands-on training experiences for workers, allowing them to practice operating equipment, troubleshooting issues, and responding to emergencies in a safe and controlled environment. Additionally, AI-powered adaptive learning platforms can personalize training programs based on individual learning needs and performance metrics, ensuring that workers acquire the necessary skills efficiently.

AI is transforming workforce readiness in the LAC energy sector by necessitating the acquisition of new skills, promoting data-driven decision-making, and enhancing operational efficiency and resilience. As AI continues to evolve, energy companies and workers alike will have to adapt to these technological advancements to remain competitive.

Recommendations for Workforce Readiness

Below we review four high-level recommendations set forth in the updated Workforce Readiness report. We believe these recommendations to be a useful guide in further positioning the region to capture employment opportunities associated with the energy transition. Moreover, these concepts will allow near-term, nontechnical, and potentially useful consensus-building avenues for the broader energy transition objectives of ameliorating climate change while enhancing economic development and reducing workforce informality and inequality.

Develop an Energy Transition Workforce Readiness Advisory Council

Each country would customize and integrate the council with its preferred members, ensuring representation from various sectors. Key members should include the ministers of Education, Environment, Labor, Finance, and Energy; the heads of the NOC, and the state power company; leaders of electrical unions and O&G unions; presidents or deans of technical and vocational education and training (TVET) schools; and prominent private sector representatives who specialize in renewable energy or are significant energy consumers.

By establishing clear parameters for the formation and operation of such councils, each country can effectively formalize the importance of employment in the energy transition and facilitate coordinated efforts toward achieving this objective.

Create Latin America Energy Transition Core Competencies

This concept seeks to establish a Latin American Industry Classification System (LAICS), akin to the North American Industry Classification System (NAICS), with the ultimate goal of expanding NAICS to encompass a harmonized standard across the Americas. It involves a regional effort to develop and curate a high-level framework for core competencies and standards for workforce development related to energy transition jobs and skills.

By fostering collaboration and consensus-building among stakeholders, this regional effort aims to develop a robust framework for workforce development in the energy transition sector, ultimately contributing to a more sustainable and prosperous future for the LAC region.

Develop Enhanced Technical and Vocational Education and Training

This effort is designed to build upon the first two recommendations through targeted integration of labor and harmonized energy transition standards and core competencies—LAICS—across the region's TVET schools and in formal curriculum, training, coursework, and administration. It aims to promote a LAC network of TVET institutions that adopt the harmonized standards. Enhancing the alignment between TVET programs and companies implementing energy transition solutions is crucial to delineating employment opportunities more precisely and assist graduates in accessing these jobs. Additionally, the implementation of a mentorship program could facilitate this alignment and explicitly foster linkages between TVET graduates and industry stakeholders.

By implementing these strategies, the region can strengthen the alignment between TVET education and energy transition sector needs, ultimately enhancing workforce readiness and facilitating sustainable economic growth across LAC nations.

Create Fossil Fuel Economy Job Reskilling

The region holds significant human capital developed in the O&G industries, particularly through NOCs. This expertise must be leveraged and transitioned toward emerging non-fossil-fuel-related activities. These efforts should also consider the highly unionized nature of these jobs. Unions can serve as key stakeholders for consensus building.

By implementing a comprehensive jobs reskilling program, LAC nations can effectively transition their workforce from the fossil fuel economy to emerging non-fossil-fuel-related activities, ensuring sustainable employment opportunities and contributing to the region's economic diversification and environmental sustainability goals.

From Transitional Fuel to Immediate Climate Response

In 2022, total LAC emissions from electricity generation using liquid fuels (diesel and fuel oil) reached 62.2 million tons of CO2 annually (OLADE, 2022). Additionally, industrial emissions associated with the use of those same fuels, primarily for thermal industrial purposes, amounted to 34.5 million tons of CO2 annually. These volumes add up to 96.7 million tons of CO2 emissions. Replacing those carbon-intensive fuels with a lower carbon intensity source like **natural gas could mean a 26%**, or 25.3 million tons of CO2, reduction in emissions annually.

Notably, if we consider that replacing a gasoline vehicle with an electric one prevents 0.208 kgCO2/km of emissions, assuming an average 10,000 km annual distance traveled, the substitution of an electric vehicle for a gasoline vehicle would mean approximately two tons of CO2 saved per year. This calculation assumes the electric vehicle effectively replaces the fossil fuel vehicle in the automotive fleet. As such, the replacement of liquid fuels with natural gas in electricity generation and industrial thermal uses could reduce emissions equivalent to taking more than 12 million private vehicles off the road.

These basic impact calculations imply other facets of the problem. First, the substitution of less carbon-intensive sources applies to end-use energy that cannot be electrified or immediately migrated to renewable energy sources. There is no real competition for the role of best renewable effort in the energy transition. Instead, lower-intensity fuels can act as one effective tool in current demand centers.

Today, renewable sources can be cost-effective in most electrical systems across the LAC region. But there are thermal energy uses and consumption segments that rely on liquid fuels because of geography, existing infrastructure, technological characteristics, and requirements for end-use energy, not to mention the costs associated with technologies still in development for source substitution (like storage). Some emerging economies' budgetary constraints cannot be overlooked. A gradual transition to lower-carbon solutions involves significant infrastructure investments.

In other words, 100% green technologies cannot immediately address some fossil fuel consumption. Some arguments downplay the value of emissions reduction through the use of natural gas. They claim that the natural gas supply chain carries a higher amount of methane emissions, which significantly impacts GHG emissions. Some of these arguments are part of various reports published by the UN Environment Programme and supported by the International Methane Emissions Observatory. They provide valuable information and analysis.

But methane emissions tied to the venting of associated gas in oil production are the greater issue. The actual chain of capture, transport, distribution, and final use is a far smaller concern. Any impact assessment should consider this reality. While global methane emissions must be slashed, these two emissions sources should not be grouped into the same category. The incremental methane emissions from increased natural gas penetration to replace a more carbon-intensive fossil fuel source would not be significant enough to negate the benefits of that replacement.

The transition of industries, power generation, and a segment of the transport sector to natural gas would yield significant benefits in the short and medium term. Not only would it substantially reduce GHG emissions, it would also capitalize on an industry that boasts decades of valuable experience. Additionally, it would leverage existing large-scale infrastructure, thereby optimizing efficiency and minimizing the need for extensive new investments. This strategic move would conserve capital and allow for the development of profound technological upgrades. Importantly, the sooner GHG emissions are curtailed, the greater the positive impact on climate change.

The landscape of long-term investments is swiftly evolving, as it constantly faces continual updates and technological advancements. Consumer demand plays a role, as well. The overall dynamic challenges traditional industries. The energy sector is not immune to these changes; acknowledging and adapting to this evolving paradigm takes time.

Natural gas is a pivotal tool for navigating this transition. It can bridge the gap between the current state of the industry and its reimagined future. Replacing liquid fuels with natural gas in power generation, especially during peak demand periods, would be more cost-effective than deploying extensive battery and storage systems (other than existing hydro). Such a move would not only mitigate immediate financial burdens but also allow the industry to refine and enhance these technologies progressively, which would pave the way for broader accessibility across many countries.

Policy Recommendations

As our assessment and analysis reveals, there are several key points the LAC region must address as it seeks to reach its Net Zero commitments and goals. Below we present a series of recommendations for actions to support those efforts. These recommendations, which span several key domains, represent essential steps toward advancing decarbonization in the region while accommodating the unique characteristics of each country's natural resources, human capital, and, notably, fiscal and regulatory capacities.

In addition, these recommendations offer pragmatic pathways for consensus-building in the near term. They present approaches that can contribute significantly to broader decarbonization and energy transition objectives. These objectives extend beyond mitigating climate change to include fostering economic development and bolstering LAC nations' global competitiveness.

Address Untargeted Fossil Fuel Subsidies

Fossil fuel subsidies and the integration of oil revenues into numerous LAC countries' fiscal frameworks must be carefully examined. Many LAC countries' economies rely heavily on oil-generated income. Consequently, any effort to shift away from fossil fuels must address the need to restructure public finances. Such a transition will take time; revenue streams within the renewable energy sector will have to be identified, as will ways to insert them into the prevailing budgetary framework.

And the lingering effect of fossil fuel subsidies on resource allocation cannot be ignored. It becomes more difficult to streamline systems when price signals diverge from rational and efficient resource utilization. This discrepancy further impedes the efficient monetization of domestic energy sources in the region, which affects countries' ability to retain a portion of this wealth as a catalyst for development.

Create a Free Market for Natural Gas and LNG

• **Governments should reduce international trade barriers as they seek to build domestic energy security.** The LAC region's abundant natural gas resources necessitate a focused effort to integrate and enhance regional energy system efficiency. Countries must monetize existing natural gas reserves in the short and medium term and promote increased utilization of current infrastructure. This approach would foster seasonal stability in domestic markets by aligning demand and supply, while simultaneously maximizing export potential to extract the full value of available reserves. It will take a comprehensive strategy that includes a renewed integration initiative, incentives for production development and capture, a focus on transportation and distribution system improvements, and the establishment of new regulations that support liquefaction and small-scale transportation technologies to address this significant regional policy challenge.

• **Governments must foster legal and regulatory reforms to facilitate increased regional and international trade.** Such efforts include enhanced permitting and development processes. They must modernize and adapt natural gas market regulatory frameworks to allow for dynamic international exchange mechanisms that incorporate LNG. LAC countries do not necessarily have a consistent history of compliance in international natural gas exchanges. As such, they must establish new mechanisms for international bilateral agreements to create confidence, adjust to new technological solutions, and enable a new phase of gas integration. The development of subregional integration platforms like those that operate in electricity integration (e.g., SISNEA in the Andean subregion, SIESUR in the Southern Cone, and SIEPAC in Central America) should not be ruled out. They facilitate integration processes and make it possible to nurture regulatory harmony.

Urge NOCs to Adopt Net Zero Targets with Timelines and Strategies

• Companies should incorporate international ESG practices that address precise CO2 reduction targets in their operations. These targets should align with each country's international agreements and commitments.

• Countries and companies must explore new financing mechanisms and linkages with ESG, like Green Bonds. If a country cannot finance additional climate performance efforts, it is difficult to talk about targets and new commitments. LAC nations have begun to issue debt linked to climate commitments. O&G operations' emissions cuts can accompany the fulfillment of these commitments. Climate finance that excludes the O&G sector must incorporate the dimension of impact and real results in terms of emissions abatement associated with sector actions. In fact, O&G companies' transition to energy companies requires the development of new financing mechanisms for their expansion in new green technologies.

Decarbonize through Natural Gas and Short-Term Decarbonization Goals

• Methane emissions is of great concern for some associated gas production wells, mainly those not connected to a grid. Natural gas policies must address this issue and the ways projects can put that methane to use. Signing the emissions pledge is a first, key step. But innovative technical and commercial solutions to the problem must be encouraged. The Unblock Computing, Crusoe Energy, Tecpetrol, Pluspetrol, and Pampa Energia effort in Argentina stands as a prime example of an innovative solution. These companies burn natural gas that would otherwise be flared to run datacenters that mine bitcoin and other cryptocurrencies. They have also incorporated AI servers to host a variety of applications.

Natural gas production fluctuations and political mandates currently leave some LAC infrastructure underutilized. Reconversions and revamping would improve natural gas opportunities. For example, reusing the Argentina - Brazil Uruguayana pipeline (and building the projected pipeline to Porto Alegre), or resurrecting the Argentina - Uruguay Casablanca pipeline, and adding new power capacity to absorb renewable energy fluctuations, or even connecting Montevideo with Porto Alegre. The building of pipelines to connect Venezuela gas fields with the Trinidad & Tobago Atlantic LNG liquefaction terminal represents a big step toward the integration of gas systems.

• The LAC power sector still uses coal and fuel oil #6. Natural gas should replace them. But in places like Peru, for example, it will take new pipelines to fully replace liquids with natural gas. The well-known Gas al Sur pipeline, which connects the Camisea Gas Project with the port city of Ilo, has multiple different routing options for replacing liquid fuels and can contribute substantially to broadening the country's use of natural gas.

In Argentina, liquid fuels are used to generate power primarily when natural gas transportation becomes congested during peak demand season (or hours). The country is currently working to increase transport capacity. Power generation companies in the country's center should soon be able to switch to the consistent use of natural gas. The investment has been marginal, but it will benefit the environment enormously (not to mention the national economy, given possible cuts to subsidies and liquid fuel imports at international prices).

Uruguay represents another possible model. While UTE projects rely heavily on liquid fuels when no renewables are available, Argentinean gas producers are eager to export natural gas to Uruguay. Commercial arrangements must be made, and Uruguay (and others) must see that a reliable supply is back in the Southern Cone.

• Diesel is currently the main energy source for energy-intensive extractive activities like mining. Many companies and countries have undertaken important efforts to decarbonize mining activity but have encountered serious technical problems. Although renewable generation can replace part of the mining industry's consumption, and it is possible to electrify part of the final energy consumption, the need for storage and the cost associated with that storage becomes a major barrier to decarbonization. Source replacement in heavy mining transport is another barrier. Small-scale LNG solutions can be a technological alternative to help decarbonize and reduce diesel consumption if they are integrated into hybrid solutions systems. These solutions are framed in energy efficiency policies for mining. As such, the sector requires additional, specific energy efficiency policies.

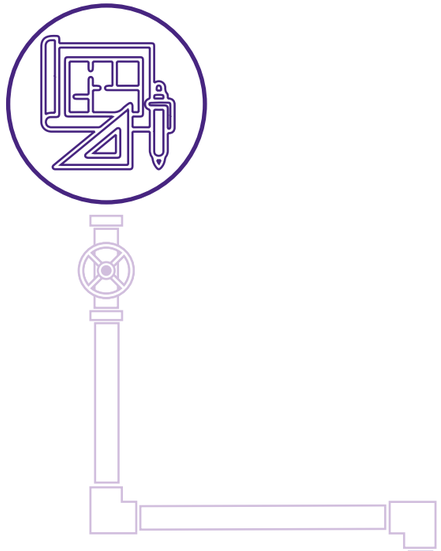
Heavy and maritime transportation present a scenario comparable to that of mining. Gasifying such transport is a financially viable solution for more immediate decarbonization. Various small-scale alternatives, like LNG for long-distance heavy transport and compressed natural gas (CNG) for shorter distances, are readily accessible.

The gasification of river and maritime transport fuel demand is a particularly viable and more immediate option, as it has already proven to be cost-effective in numerous LAC countries. For example, the ferry that runs between Montevideo and Buenos Aires uses LNG for its journeys. But while it would seem cruise lines could also use LNG, as many operating in the Atlantic have the potential to utilize natural gas, the maritime natural gas supply network faces disruptions in the Caribbean, particularly in Jamaica and Florida, in the U.S.

• Hydrogen and natural gas sector technology is evolving rapidly. New uses of hydrogen and its derivatives, as well as improvements in materials like new steel alloys for related infrastructure, are still to be discovered. Authorities must focus on strategic planning when transitioning industries to carbon neutrality. Furthermore, policymakers should encourage and support research on the adaptability of natural gas infrastructure for hydrogen use, including the case of blended natural gas and hydrogen in pipelines. This approach could rapidly expand hydrogen delivery infrastructure and contribute to further decarbonization goals. Officials should also prioritize thorough analyses and risk assessments for the conversion of existing LNG terminals to ensure the success and safety of hydrogen-related projects.

Natural gas asset investments must be approached with an eye toward transitioning within the next two decades. Natural gas is a cleaner transitional fossil fuel that balances the need to decarbonize with efficient resource utilization and manageable investments. It plays a key role in cleaner industry development across LAC nations in the short and medium term.

> These recommendations can serve as a blueprint for navigating the complex challenges and opportunities inherent in the LAC region's transition toward a more sustainable energy future. As countries embrace these recommendations, policymakers, industry stakeholders, and other relevant actors can collectively pave the way for a greener, more prosperous future for Latin America and the Caribbean.



Annex I: Literature and Sector Review for Research Questions and Context

Overview of Net Zero Goals and Decarbonization in the LAC Region

Context and Trajectory

Globally, three quarters of GHG emissions come from the energy sector. In Latin America, that sector accounts for only 55% of such emissions. Within that block, 20% comes from power production.[74] Renewables account for 60% of current energy production—well above the global average. With that, the next steps in the decarbonization process are clear. Investment in emissions-free energy production remains a hurdle not just for Latin America but for the entire world, as well. Everyone must continue to pursue new renewables projects. The reduction of emissions wherever possible is equally important.

Wood Mackenzie's Raphael Portela states that Latin America's "NOCs have the financial strength to invest, as record cash flows are allowing for a reset of balance sheets."[75] As Latin America's most powerful organizations, inside and outside of the energy sector, NOCs have the resources and the obligation to make the necessary changes. Some changes do not require major overhauls. For example, "cost is rarely the main factor to methane abatement," state Andrew Howel and Andrew Baxter on the Energy Monitor website.[76]

The transportation sector is the LAC region's main CO2 emissions contributor, at 40% of total emissions. Of that 40%, road transportation contributes 92%.[77] Some believe that road transportation will be the final stage of the decarbonization process, in LAC nations and the rest of the world. Battery and charging resources could take decades to rival the convenience and energy density of petroleum.

IEA Latin America Energy Outlook

The International Energy Agency's 2023 comprehensive report includes current and projected trends in energy production and use in the Latin American region. It uses three models, STEPS, APS, and NZE, to create separate potential paths for the LAC region, as follows:

- **Stated Policies Scenario (STEPS):** A holistic look at current capabilities and future measures or advancements that have been indicated. STEPS is the most conservative scenario. It leads to a 2.4˚ C temperature change in 2100.

- **Announced Pledges Scenario (APS):** An intermediate model in which all governments meet and are proactive on passing climate change-related policies. Business and stakeholder commitments are also considered if they have been made publicly and align with, or advance government-set goals. This projection weighs more heavily on the possibilities set in government and other statements, and less on proven capabilities. Therefore, this projection is more liberal, at a 1.7˚ C temperature change by 2100.

- **Net Zero Emissions by 2050 Scenario (NZE):** A hardline model for achieving only a 1.5˚ C change by 2100.

[74]Financing the Energy Transition in Latin America and the Caribbean: An Incomplete Puzzle - Center on Global Energy Policy at Columbia University SIPA | CGEP

[75]Are NOCs rising to the energy transition challenge? | | Wood Mackenzie

[76]National oil companies (NOCs) lag on methane. Finance can help. (energymonitor.ai)

[77]Transporte 2050: el camino hacia la descarbonización y la resiliencia climática en América Latina y el Caribe (iadb.org)

Using IEA and other guidance, the report explores ways to turn the STEPS into APS and ideally into the NZE. LAC NOCs will play a significant role in those efforts. The IEA further explores the ways in which countries, and primarily NOCs, can work to bring these scenarios to fruition. Pertinent sections of the report are as follows:

Total Energy Supply

• Fossil fuel consumption stands as the most pertinent area of focus for LAC region decarbonization. The IEA examines discrepancies between the supply and consumption of electricity from fossil fuels in each of its models. The IEA states that neither STEPS nor APS meets Net Zero. In fact, STEPS indicates an increase in oil and natural gas supply. Latin America already has a large portion of hydropower-generated electricity. This resource offers a consistent power baseload for a substantial portion of the region. However, projections indicate that climate change will augment the levels and regularity of precipitation and the IEA states that existing hydroelectric plants will see an overall 8% drop in efficiency.[78]

Final Energy Consumption

• Oil represents almost half of all energy consumed in the LAC region. Of that half, the transport sector takes the lion's share. Within the transport sector, final consumption modeling shows the largest discrepancy between STEPS and APS. The industry and buildings sectors follow similar trajectories. The transport sector has completely divergent modeling trajectories. Clearly there is a stark difference between what is proposed and what is happening.

Transport

•Transportation will likely be the last sector to be decarbonized for all economies, regardless of wealth. However, the LAC region has some important characteristics that set it apart from other regions. LAC nations, led by Brazil, operate a large percentage of transport on biofuels. On average, 86% of transport relies on oil, which is less than the 91% global average. STEPS anticipates a near doubling of car ownership in the LAC region by 2050. Two and three-wheeled vehicles undergo less of an uptick in the model, despite high ownership in countries like Colombia and Argentina.

Tougher fuel economy standards, especially for medium and heavy freight trucks, will help meet APS expectations. LAC fuel consumption is just above the global average, but only five countries have light-duty fuel economy standards. Mexico, Costa Rica, and Chile have strong EV pledges under APS, with an adoption rate of up to 30% by 2030. Only a 40% adoption rate is projected for the region as a whole by the late 2040s. The aviation sector has been growing most rapidly and is set to double by 2050, with oil meeting 80% of that demand.

The focused implementation of electric two and three-wheeled vehicles could be a decarbonizing strategy, as migration to LAC cities continues the upward trend that began in 1993. Public transportation could also help close the gap between STEPS and APS. As LAC cities grow, aging transportation systems will have to be replaced, opening the door to decarbonization. Bogota has the largest electric bus fleet of any city outside of China. More than 45 cities in the LAC region have invested in electric bus systems.

Industry

• Industry in the LAC region is less energy-intensive than the global average. Non-energy intensive industries account for almost half of energy consumption in the sector. Food and mining dominate the sub-sectors within this portion. Chemicals, steel, and iron are the primary energy-intensive industries. Brazil and T&T are large chemical producers; Brazil produces the most steel and iron, with Mexico and Argentina following.

Decarbonizing the energy-intensive LAC sectors presents the same hurdle as it does for the rest of the world: large infrastructure and building investment. However, newer energy-intensive industrial facilities are more energy efficient, and industry has served as an important aspect of economic recovery in recent years. Investment is the primary contributor to meeting APS expectations.

[78]Latin America Energy Outlook. International Energy Agency. 2023. (Section 2.2; page 70)

Buildings

• Residential buildings account for around 75% of energy consumption in the buildings sector. **Within residences, cooking and appliances account for 20% of energy consumption. Electricity, the most significant energy source, accounts for 45% of this energy. Costa Rica has the highest ratio of building electricity use, at 77%.** About 74 million LAC nation citizens do not have access to clean cooking facilities and rely on biomass. Minimum energy performance standards for end-use appliances will be an important step toward reaching APS standards. For building construction, only a handful of LAC countries have regulations on building codes for sustainable construction and creating low-energy buildings. Only proper enforcement of regulations will make a change in this sector.

NOC Dashboard and Data

Ecopetrol

• Ecopetrol has created three VP-level offices in sustainability, and plans to reach Net Zero by 2050. It seeks a 25% reduction in emissions by 2030 and a roadmap that will look to reduce emissions from venting and flaring, create operational energy efficiency, build a renewable energies portfolio, and expand hydrogen and CCS in the midterm. Ecopetrol has posted a net profit nine out of the last ten years. It does not sell green bonds. **It improved its flaring-to-production ratio and its overall emissions-to-production ratio. It has 400 MW of installed renewable projects, 85% of which are solar.**

YPF

• YPF has a dedicated Department of Sustainability and Energy Transitions Risk as well as a sustainability committee with six directors. **It has stated it plans to reach Net Zero by 2050 and reduce methane emissions 30% by 2030.** YPF has recently had net negative profits but received its first green bond in 2022 with a total US$ 63.9 million through YPF Luz. YPF initially improved its flaring-to-production ratio but then returned to its previous levels.

YPF has not significantly reduced its emissions-to-production ratio, although that ratio improves when the company operates at a profit. It has demonstrated a commitment to expand renewable energy in partnership with YPF Luz (222 MW renewable energy installed capacity). It has also committed to expand wind farms (it currently has six: the first was deployed in 2017, three more came in 2019, and two in 2021).

YPF has also defined a New Business Department to focus on new fuels, hydrogen, and other transformation projects. It is developing an LNG liquefaction plant in Bahia Blanca, and its co-owned subsidiary, Profertil, is analyzing fertilizer production based on YPF-produced green hydrogen.

Pemex

• Pemex created a sustainability committee in May 2023. It does not have a dedicated office or department for sustainability, decarbonization, or the energy transition. The committee, which is made up of Pemex Administrative Council members, including executive officers and high-ranking government representatives, has been tasked with aligning the state company with ESG goals.

But those goals are unclear. There is no Net Zero road map. In its 2023-2027 business plan, Pemex acknowledges the impact that the energy transition is having on its operations. Though the company recognizes the need to address environmental concerns and make commitments to implement more sustainable practices, it sees the oil and gas industry as having an optimistic outlook over the long-term.

Within the observed timeline, Pemex has not issued bonds that are specifically tied to green projects. In 2024, Fitch Rating downgraded Pemex's Long-Term Foreign and Local Currency Issuer Default Ratings (IDRs) to B+ from BB-. The downgrade reflects the company's continued weak operating performance, which further

limits its ability to source financing from banks, investors, and suppliers. Pemex has received over $40 billion in government transfers over the last five years, while operating at a loss for eight of the last ten years.

Pemex has not reduced its flaring-to-production or emissions-to-production ratios. The company made significant progress in decreasing those ratios between 2015 and 2017, but then returned to 2015 levels.

The CFE, Mexico's state-owned electric company, is responsible for increasing installed capacity. As provided by its laws, Pemex is a decentralized agency whose primary function is to carry out the activities of exploration, exploitation, and other actions demanded by the operation and strategic management of the oil industry. Activities related to renewable or alternative energies represent a much smaller role in the business.

Petrobras

• Petrobras has created a dedicated office to focus on the energy transition and sustainability. The company has a Net Zero plan, but it does not specify the date Net Zero will be attained. It has stated goals to reach a 25% reduction in absolute operational emissions by 2030.

Petrobras has maintained its profit in the last few years and in 2022 pursued a $1.25 billion loan. It has recently improved its flaring-to-production ratio, but the downward trend remains uncertain. Like YPF and Pemex, Petrobras reduced its emissions-to-production ratio for a time (between 2018 and 2020), but the ratio then increased. Petrobras has invested in renewable energy, biofuels, wind, solar, and carbon recapture technologies.

ENAP

• Enap's General Manager, Julio Friedmann, stated that ENAP had a "historic" year in production and profit in 2022 and that 2023 would likely be as good or even better. With oil companies seeing record years during the COVID19 pandemic, and Russia's invasion of Ukraine sending oil prices skyrocketing, many are predicting and planning for a world with oil and gas for the long term. However, Friedmann states that ENAP has a plan for 2040 that includes prioritizing low carbon fuel sources.

ANCAP

• ANCAP, which lies outside its counterparts in that it does not engage in oil production, operated at a profit in 2021[79] and 2022.[80] Recently, it offered a record seven offshore oil drilling licenses to foreign bidders.[81] The licenses are in unproven areas, or "wildcats." However, the ambitious number signals a commitment to petroleum for the foreseeable future.

ANCAP is leading the H2U Offshore chapter of the Hydrogen Roadmap of Uruguay through a system of international tenders (rounds) for private parties to produce hydrogen and derivatives from offshore wind at their own cost and risk. Since November 2021, more than 100 meetings have been held with more than 70 companies interested in this development. In addition to the exchange with the industry, a first draft of the bidding terms and contract model were officially launched in 2023. Additionally, the scheduling of virtual data-rooms is available so interested parties can access information on offshore Uruguay to carry out preliminary feasibility studies.

ANCAP has advanced its hydrogen-oriented strategy by way of a specific project for synthetic fuel production using biogenic origin CO2 from the ALUR plant in Paysandú. HIF Global's project in Uruguay was selected in an international competition. The project produces 180,000 tons of e-gasoline per year from the capture of 710,000 tons per year of CO2 from the combustion of biomass and distillation of alcohol from cereals and the production of 100,000 tons of green hydrogen per year. Authorities plan to install a 1 GW alkaline electrolyzer and another 2 GW from photovoltaic and wind sources. The project will require almost US$ 1.985 billion for CO2 capture, methanol production, and synthetic gasoline completion, and another US$ 2 billion for the installation of wind turbine parks, photovoltaic farms, and transmission lines within a radius of up to 180 km from the city of Paysandú.

[79] Ancap: estatal uruguaya tuvo ganancias en 2021 pero perdió en sector monopólico (bloomberglinea.com)

[80] Uruguay's Ancap profitable despite adjusting prices below import parity — MercoPress

[81] Energy giants place tentative bets on oil finds in 'wildcat' Uruguay | Reuters

OLADE's Energy Panorama for Latin America and the Caribbean 2022

In accordance with the OLADE Energy Outlook, under a business-as-usual scenario (BAU), which considers the existing policy framework and committed NDCs, the share of r**enewable energy (RE) considering primary energy supply will be stable at 30% in 2050.** Under one possible Net Zero scenario, **RE share increases to 56%.**

Under a BAU scenario, an additional 175 GW of wind and solar would be installed with an estimated 205,557 MM USD investment by 2050 .

The RELAC initiative, which includes 16 countries, requires the installation of an additional 86 GW of wind and solar or what is currently installed until 2030, which implies an estimated 98,500 MMUSD investment. This arrangement would require an additional 31,300 MMUSD investment under the BAU.

Net Zero requires the installation of an additional 457 GW of wind and solar until 2050, which implies a 312,000 MMUSD incremental investment over the BAU.

Under a Net Zero scenario, **oil participation in the primary energy matrix drops from an initial 38% to 22%. Natural gas has a greater role in decarbonization, representing 19% of the primary energy matrix.**

Even under the Net Zero scenario, fossil fuel participation continues to represent 44% of the primary energy matrix in the region.

Prospective of Compliance with Commitments made in NDCs (Polìticia energética y NDCs en América Latina, OLADE, 2018)

OLADE developed a study to analyze the efficacy of current LAC country energy development policies in contributing to the achievement of NDCs on GHG emission reductions by 2030 goals. To this end, an energy foresight exercise was carried out for LAC subregions, with 2015 as the base year and 2030 the horizon.

The study concluded that, under the assumptions of the current policy scenario (EPA), none of the subregions analyzed would be able to meet the emissions reduction targets referenced in their countries' NDCs; therefore, the proposal of a more aggressive policy in terms of energy efficiency and penetration of renewable energies is justified.

About the Authors and Research Team

Alfonso Blanco is a recognized expert with a distinguished career in energy and environment. He has led multiple energy transformation processes in Latin America and the Caribbean. He has advised decision-makers on regulatory issues, energy policy, energy and climate change diplomacy, project formulation and evaluation, business development, and financing models in Latin America and the Caribbean. He is the former Executive Director of the Latin America Energy Organization, a senior consultant for development banks, and was one of the leaders of the Uruguayan energy sector transformation (98% renewable energy in electricity in 2018).

He holds a degree in engineering from the Faculty of Engineering of the University of the Republic of Uruguay (UdelaR), and an MBA from the ORT University. He has postgraduate studies in Economics, a diploma in economics from the Economics Department of the School of Social Sciences of the UdelaR, Uruguay, and an Executive Certificate in Public Policy from the Harvard Kennedy School.

Dario Febre is Director of Business Development at SEMPEN, a startup devoted to producing the fuels for the energy transition. Dario has more than 25 years' experience in Latin America's energy sector. He has lived in Argentina, Peru, Chile, and Mexico, and covered other countries like Brazil, Bolivia, Colombia, Panama, and the U.S. He managed important project portfolios that included thermal, renewable, and infrastructure ventures, through which more than 1.5 GW were awarded via public auction. He held positions at ENGIE Group in strategy, portfolio management, communications, business development and internal auditing from 2006 to 2021. As an entrepreneur, he has developed the commercial strategy for Splight Artificial Energy and Manta Verde, an agricultural business. He recently joined SEMPEN to support its founder in business development and strategy. Dario has collaborated with the Institute of the Americas since 2009.

Dario is a Chartered Public Accountant and holds an MBA from Universidad Torcuato Di Tella. He is also a specialist in energy regulation from the University of Buenos Aires. Dario is married and has two sons. He is a passionate sailor.

Jeremy M. Martin is Vice President, Energy & Sustainability at the Institute of the Americas, an inter-American public policy think-tank located at the University of California San Diego. The Institute of the Americas Energy Program works to foster a deeper understanding of the most critical energy issues facing the Western Hemisphere.

Jeremy spends his time delving into the geopolitics of energy and closely following energy industry trends and policy issues across the Americas and is a frequent commentator and writer on Latin American and energy issues. Martin has testified before the U.S. Congress on energy issues in Latin America, teaches a graduate seminar in Latin American Energy Politics at the University of San Diego, and serves as Curator of the energy section of the U.S.-Mexico Network, an online forum hosted by the University of Southern California.

Thanks to his upbringing, he is a diehard Red Sox fan, Civil War buff, and news junkie. Jeremy graduated with honors in history from The Citadel, the Military College of South Carolina and a master's in international affairs/ international development from American University in Washington D.C. He has yet to achieve his lifelong dream of being a stand-up comic.

Gordon M. Magne served as principal research assistant for the report. He is a recent graduate with a master's in international affairs from the University of California San Diego. At UC San Diego he studied the policy and engineering hurdles for the U.S. in transitioning to an emissions-free economy, climate policy of the State of California, and political and energy structures of Latin America.

Gordon also holds a bachelor's in classics from the University of Colorado at Boulder. He speaks Spanish and French. He has an affinity for tacos and early morning swims in the ocean.

"Research conducted by Anne Charles and William Lozano-Arciniega on National Oil Companies (NOCs) and Sustainable Development Goals (SDGs) was also integral to our NOC analysis, while previous research done by the entire team of Non-Resident Fellows at the Institute of the Americas greatly aided the section on workforce development and human capital. Additionally, this report was improved by input from an outside review conducted by Patricia Garip, who provided key overarching comments and areas for further research; she also noted the need for deeper analysis and understanding of the role hydrogen may play for the region's energy future and decarbonization pathways. That topic could serve as the centerpiece of a follow-on research project.

Authors' Note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