JUST ENERGY TRANSITION

Conceptual framework for the region
Analysis in the national context

IDFC International Development Finance Club FACILITY

CAF DEVELOPMENT BANK OF LATIN AMERICA AND THE CARIBBEAN

Just Energy Transition / Conceptual framework for the region, Analysis in the national context

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Altamira, Caracas (Chacao) Miranda 1060, Venezuela. RIF: G200015470

Contribution of CAF to the Climate Facility of the International Development Finance Club

Report coordinated by the Climate Action and Positive Biodiversity Division (GACBP, in Spanish), the Knowledge Division (GC, in Spanish) and the Physical Infrastructure and Digital Transformation Division (GIFTD, in Spanish).
Edgar Salinas, executive principal, Operations and Green Financing (GACBP).
Walter Cont, senior executive, Sectoral Analysis (GC).
Juan Ríos, executive principal, Transport and Energy (GIFTD).

Authors
The GME team (in alphabetical order) included Agustín Ghazarian, Coline Champetier, Darío Quiroga, Francisco Baqueriza, Nicolás Barros, Laura Souilla, Ramón Sanz, and Roberto Gomelsky.
The authors thank Edgar Salinas, Walter Cont, and Juan Ríos for their comments, suggestions, and support for the development of this document.

Editorial Management
Strategic Communication – CAF.

Universal neuroinclusive graphic design, with principles of accessibility and visualization for neurodivergent readers
CLEIMAN - https://cleiman.com

Photography
Cover: ©AdobeStock
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Just Energy Transition

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CONTENTS

List of abbreviations 10

Foreword 13

Executive summary 16

Chapter 1
Objectives 21-23

1. General objectives 22

2. Specific objectives 23

Chapter 2 Development of the concept of just energy transition — 24-68

1. Climate change 25

- **Climate change and energy** 26
- **Energy transition and equity** 36
- **The starting point in LAC and the analyzed countries** 40
- The transition in the energy sector in Latin America and the Caribbean 40
- Energy resources in the region 41

2. The concept of energy transition according to the different countries and some major players 44

- **Compilation of ideas and definitions on the energy transition** 44
- Paris Agreement- Energy transition components 44
- Definition of the United Nations Development Programme 46
- Definition of the International Monetary Fund 46
- Definition of the International Energy Agency 47
- Definition of the International Renewable Energy Agency 49
- Definition of the World Bank 51
- **Other concepts associated with the just energy transition** 52
- **Organization of the main elements of energy transition by topics** 54

3. Conceptualization of the just energy transition in Latin America and the Caribbean 65

- **Some differential characteristics of LAC that should reflect on the energy transition** 63
- **The just energy transition in Latin America and the Caribbean** 67

Chapter 3 Definition of indicators — 69-112

1. Dimensions and topics of the just energy transition 70

- **Dimensions of the just energy transition** 70
- **Dimensions and associated topics** 71
- Institutional aspects – Organization of the energy sector 73
- Economic and energy aspects 75
- Social aspects – Reduction of the energy gap 80
- Environmental aspects 81
- Financing 82

2. Indicators by dimension and topic 85

List of indicators	84
Description of the indicators	86
Institutional aspects	86
Economic and energy aspects	90
Social aspects – Reduction of the energy gap	100
Environmental aspects	106
Financial aspects	110

3. Update on the indicators 112

Chapter 4 Indicators by country for the base line 113-117

Works cited 118-119

TABLES AND GRAPHICS

Table 1.	Dimensions, topics and potential indicators (IESAF scheme)	20
Table 2.	Participation of emissions by source (2019)	36
Table 3.	Participation of energy sources in each country (2019)	42
Table 4.	Potential dimensions, topics and indicators (IESAF scheme)	85
Table 5.	Indicators by country for the base line (2019)	114
Graphic 1.	Dimensions and topics of the just energy transition (JET)	19
Graphic 2.	Greenhouse gases by sector, world total (2019)	27
Graphic 3.	Greenhouse gases and consumption by source, energy sector, 2019 (%)	30
Graphic 4.	Greenhouse gases from the energy sector (tCO_2eq)	31
Graphic 5.	Greenhouse gases by sector in LAC (2019)	32
Graphic 6.	Greenhouse gases in the energy sector by source, global versus LAC, 2019 (%)	34

Graphic 7.	Greenhouse gases to GDP, 2019 ($kgCO_2e$/thousands of USD)	35
Graphic 8.	Total energy consumption per capita (kWh-year/capita) and GDP per capita (current 2019 USD/capita)	39
Graphic 9.	Pathways to energy transition	50
Graphic 10.	Dimensions and topics of the just energy transition (JET)	73

List of abbreviations

BAU	business as usual
CAF	CAF – Development Bank of Latin America and the Caribbean
CIER	Regional Energy Integration Commission (*Comisión de Integración Energética Regional*)
CSP	concentrated solar power
DANE	National Administrative Statistics Department (*Departamento Administrativo Nacional de Estadística*)
DG	distributed generation
ESCO	energy services companies
FOSE	Electricity Social Compensation Fund (*Fondo de Compensación Social Eléctrica*)
GHG	greenhouse gases
HIES	household income and expenditure surveys
IEA	International Energy Agency
IFI	international financial institutions
ILO	International Labor Organization
IMF	International Monetary Fund
IPCC	*Intergovernmental Panel on Climate Change*
JET	just energy transition
LAC	Latin America and the Caribbean

MEPS	*minimum energy performance standards*
MDGs	millennium development goals
NDC	nationally determined contributions
PMR	Partnership of Market Readiness
SDGs	sustainable development goals
UNFCCC	United Nations Framework Convention on Climate Change
UPME	Colombia's Energy Mining Planning Unit (*Unidad de Planeamiento Minero Energético de Colombia*)
WEC	World Energy Council

Foreword

The Paris Agreement was signed on December 12, 2015, with the participation of 196 countries and in the context of the United Nations Climate Change Conference (COP21). The Paris Agreement is a legally binding international treaty on climate change. Its **purpose is to limit global warming to below 2°C** (if possible, 1.5°C) compared to pre-industrial levels.

In order to attain this goal, countries intend to limit greenhouse gas (GHG) emissions as soon as possible. **The Paris Agreement invites countries to formulate and submit long-term development strategies with low GHG emissions**. The global economy has historically undergone energy transition processes. The first one was from firewood to coal; the second, from coal to hydrocarbons; the third, the introduction of natural gas; and now this fourth energy transition entails the use of low or zero-emission sources. **The difference with the others is that, in addition to supplying the growth in demand, it will seek to replace, in advance, the sources adopted in the first and second energy transitions**.

Energy transition requires a transformation of the current market practices, production structures, and regulatory frameworks, as well as a significant change in the energy sources used for production and recreation activities. It also requires changes in consumption habits, behavior, and demand.

Decarbonization and emission limitation imply a significant reduction in the use of fossil fuels which, in turn, will create the need to sink assets and will generate financial impact on the value of companies, their assets, and liability refinancing in order to finance such assets (OECD, 2021).

Therefore, **energy transition should mobilize a large amount of capital to reform the energy system, compensate those who will sink productive capital earlier than expected, and disincentivize non-clean energy sources**.

In order to mobilize the required capital, it is necessary to promote market mechanisms that internalize social costs in line with the Coase Theorem (Coase, 1960) or use prices as price signals to correct any externality in line with Pigou (Pigou, 1932). Understanding financing, regulation, and tax mechanisms is vital to obtain the incentives required to mobilize the will of the economic actors.

The promoted mechanisms must envisage market schemes as well as subsidies or regulations that modify relative prices and incentivize the adoption of clean energy.

The concept of just energy transition is increasingly being discussed in governmental and multilateral environments. The discussion focuses on highlighting the fact that the transition must consider that the developing country parties to the Paris Agreement will take longer to achieve this, as they will have to attend to an improvement in the standard of living of their inhabitants and a reduction in emissions in a balance way, based on equity and in the context of sustainable development and the efforts to eradicate poverty.

This document presents a just energy transition approach for Latin America and the Caribbean (LAC) and a methodology to characterize the energy transition process in each country starting from certain indicators. In a first exercise, the proposed methodology is applied in a sample of countries with different energy matrices and climates, including Brazil, Colombia, Mexico, Peru, and the Dominican Republic.

This report has been organized as follows:

- The first chapter presents the general objective and the specific objectives.
- The second chapter, related to the concept of climate change, is divided into three sections, namely:
    - The first section focuses on defining the relation between climate change, energy transition, and the distinctive features of the region, compared to other regions.
    - The second section compiles the definitions of climate change made by global organizations and the analyzed countries.
    - The third section proposes a concept of just energy transition in LAC based on the information in the previous chapters.
- The third chapter presents a series of indicators, classified by dimension and topic, that allow for a follow-up on the just energy transition process in LAC.
- The fourth chapter presents the indicators for the base line of the five countries under analysis together with the follow-up methodology.

Executive summary

Executive summary

The following are the objectives of this report:

- To compile information on the definitions of the concept of energy transition made by different international organizations;
- To propose the concept of just energy transition based on the specific characteristics of the Latin American and Caribbean region;
- To present the methodology used to develop the indicators required to follow up on the transition from the concept of energy transition and the analyzed scenarios;
- To evaluate the indicators for the base line of the five analyzed countries.

As regards climate change, energy transition and the starting point for this study, the countries in LAC are characterized by:

- low penetration of coal in their energy matrixes and greater penetration of natural gas than in the rest of the world;
- lower emissions per gross domestic product (GDP) than in the rest of the world but higher than in the developed countries that have been implementing energy transition measures;
- high poverty levels together with low industrialization levels; therefore, an increase in consumption is foreseen based on the expected development;
- median income and median energy consumption but, in general, a portion of the lower-income population suffers from coverage and access to energy issues;

- rising total energy demand growth rates in the future, even when applying strong efficiency enhancement policies, which implies that the growing energy supply must be considered;
- Primary energy supply with a large share of renewable energy, not only for power generation but also in biofuels, which implies that there will be less substitution of facilities than in the rest of the world. However, some of these assets have not completed their useful lives yet;
- Large reserves of renewable and fossil resources, allowing for specific diversification of sources in each analyzed country.

This is why energy transitions in the region must take into account their own characteristics.

The **just energy transition** is an energy system conversion process that seeks to gradually **reduce greenhouse gas emissions** by promoting the use of technologies which employ the resources available in the region and prioritizing those that contribute more to **economic growth**. Its purpose is to reach net zero emissions while maintaining the approach of **enhancing the standard of living**, aiming at one that is compatible with a decent life. This concept is in line with the Paris Agreement, which establishes that developing countries will take longer to attain these objectives and that the process should be based on equity, in the context of sustainable development and the efforts to eradicate poverty.

This transition implies accelerating the introduction of clean, economically competitive technologies and the enhancement of energy efficiency in the value chains of the energy sector.

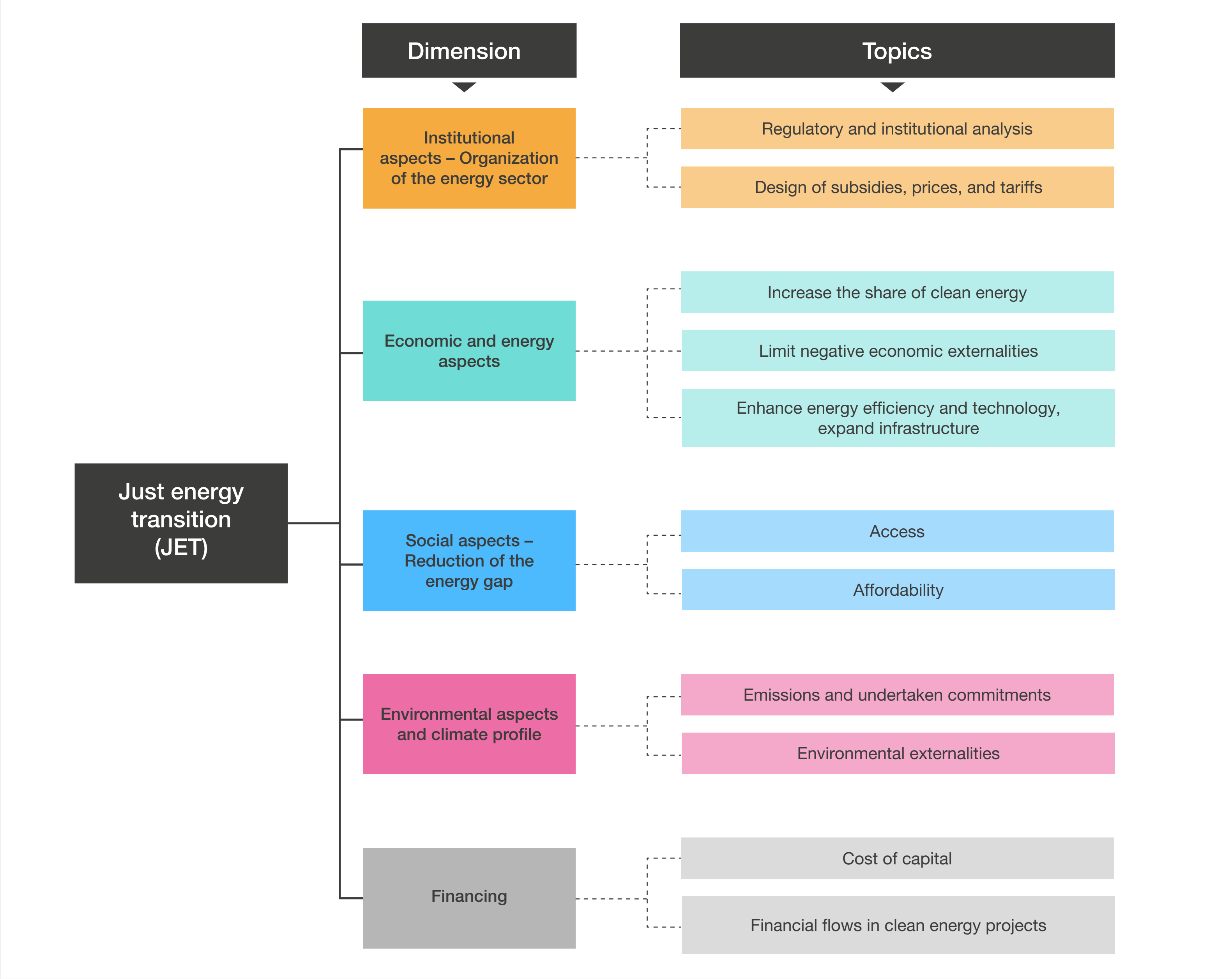
Clean technologies are those that generate low or zero emissions (renewable energy, natural gas, nuclear, certifiable biomass, and biofuels) as well as new developments (low-emission hydrogen, capture processes, carbon use and storage) whereas energy efficiency implies electrifying the demand, optimizing the transmission and distribution systems, and converting the equipment.

Just energy transition is met by aligning the following:

1. The **technological solution**, which occurs when the costs of production, logistics, and clean energy supply to consumers, measured in levelized costs, are lower than those of high-emission energy sources.
2. The r**egulatory solution**, which arises when regulations that promote clean technologies and internalize remediation costs are developed, the participation of highly polluting energy sources is limited, and tariffs and Incentives that promote energy efficiency are developed.
3. The **market solution**, obtained when carbon price mechanisms are implemented through taxes or emission certificates to internalize the remediation costs originating from the generated emissions.
4. **Financing**, obtained when prices and international and Treasury contributions are connected, which balances all the inhabitants' coverage and affordability as well as cost and investment recovery.

The report develops a methodology to follow up on transition indicators, organized through the scheme known as IESEF – for the first letter of the topics in it – which is shown below:

Graphic 1 Dimensions and topics of the just energy transition (JET)



Source: GME-CAF (July 2023).

Table 1 presents the list of indicators by dimension and topic

Table 1 ▶ Dimensions, topics, and potential indicators (IESAF scheme)

Dimensios	Topics	Index	Potential indicators
I - Institutional aspects – Organization of the sector	1. Regulatory and institutional analysis	I-1.1	Rules and governance of the energy sector
		I-1.2	Existence of energy transition strategies
		I-1.2.bis	Effectiveness of energy transition strategies
	2. Design of subsidies, prices, and tariffs	I-2.1	Subsidies to fuels (% of GDP)
		I-2.2	Total expenditure on subsidies (BUSD) and expenditure on subsidies to electricity (BUSD)
E - Economic and energy aspects	1. Use of local resources	E-1.1	Proven reserves of local resources
		E-1.2	Dependence on net energy imports (%)
	2. Introduction of energy transition technologies	E-2.1	Share of renewable energy in total final energy consumption and power generation (%)
		E-2.1bis	Installed renewable generation capacity (GW)
		E-2.2	Energy intensity measured according to primary energy and GDP (TJ/MUSD PPP)
		E-2.3	Energy conversion and distribution efficiency (%)
		E-2.4	Energy intensity by economic sector (TJ/MUSD PPP)
		E-2.5	Energy intensity of the residential sector (TJ/household)
		E-2.6	Penetration of electricity in the transportation sector (%)
		E-2.7	Penetration of natural gas and hydrogen in the transportation sector (%)
	3. Economic externalities and job creation	E-3.1	Installed capacity (GW) and value of stranded assets (MUSD)
		E-3.2	Number of formal employees associated with existing value chains
		E-3.3	Number of jobs associated with energy transition projects (thousands of job positions)
S - Social aspects Reduction of the energy gap	1. Access	S-1.1	Share of the population with access to electricity
		S-1.2	Share of the population whose primary energy source consists of clean technologies and fuels
		S-1.3	Energy use per capita
		S-1.4	Quality of energy services
	2. Affordability	S-2.1	Final tariff by sector and fuel
		S-2.2	Share of household income devoted to fuel and electricity, for the total and for the 20% poorer households
A - Environmental aspects and climate profile	1. Emissions and undertaken commitments	A-1.1	Total GHG emissions per year and sector ($MtCO2_e$)
		A.1.2	Total GHG emissions per GDP unit and per capita ($MtCO2_e$/MUSD PPP and tCO2e per capita)
	2. Environmental externalities	A-2.1	Number of people directly affected, attributed to disasters per 100,000 inhabitants
		A-2.2	Vulnerability and preparation for climate change
F - Financing	1. Cost of capital	F-1.1	Cost of indebtedness of the private sector
	2. Financial flows in clean energy projects	F-2.1	International financial flows towards developing countries to support research and development of clean energy and renewable energy production, including hybrid systems
		F-2.2	Fiscal/tax dependence of productive chains related to hydrocarbons

Source: GME-CAF (July 2023).

Finally, it is recommended that this list of indicators should be updated on an annual basis.

1 Objectives

1. 1. General objective

The objective of this report is to develop the concept of just energy transition applied to five countries in LAC, starting from a particular analysis of their national conditions, the regional context, and the complementary literary review of existing agreements and publications.

2. Specific objectives

The specific objectives of this report are:

i. to assess the specific conditions of the analyzed countries in terms of regulatory framework, strategies, commitments, economic matrix, etc., as well as the regional context, and technical considerations applicable to power systems in Latin America;

ii. to compile information on the concept of energy transition in different international organizations;

iii. to propose the concept of just energy transition based on the specific characteristics of Latin America and the Caribbean;

iv. to present the methodology required to develop the indicators that will allow us to follow up on the transition from the concept of just energy transition;

v. to establish a control and follow-up panel of these indicators.

2 Development of the concept of just energy transition

1. Climate change

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992. It established an international treaty to fight the causes of climate change as well as its adverse effects.

The Convention eventually gave way to the Kyoto Protocol, effective as of February 16, 2005, whereby quantitative goals were set to reduce greenhouse gases in the Annex I countries.

The definition of climate change according to the UNFCCC is “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (UNFCCC, 1992).

Later, in 2015, the Paris Agreement[1] was adopted as a more ambitious instrument with the participation of all the Parties (countries in Annex I and non- Annex I) in

1 Paris Agreement

connection with the goal set in its Article 2 of reinforcing the global response to the climate change threat in the context of sustainable development and the efforts to eradicate poverty. To attain this goal, it is necessary:

A to maintain the increase in the mean global temperature well below 2 °C with respect to pre-industrial levels, and continue the efforts to limit this temperature increase to 1.5 °C with respect to pre-industrial levels, acknowledging that this would considerably reduce the risks and effects of climate change;

B to increase the capacity to adapt to the adverse effects of climate change and promote resilience to the climate and development with low-emission greenhouse gases so that food production is not compromised;

C to position financial flows at a level that is compatible with a pathway leading to development that is resilient to the climate and produces low greenhouse gas emissions.

Climate change and energy

All over the world, around 50,000 million tons of GHG are emitted every year. Graphic 2 summarizes the origins of these emissions.

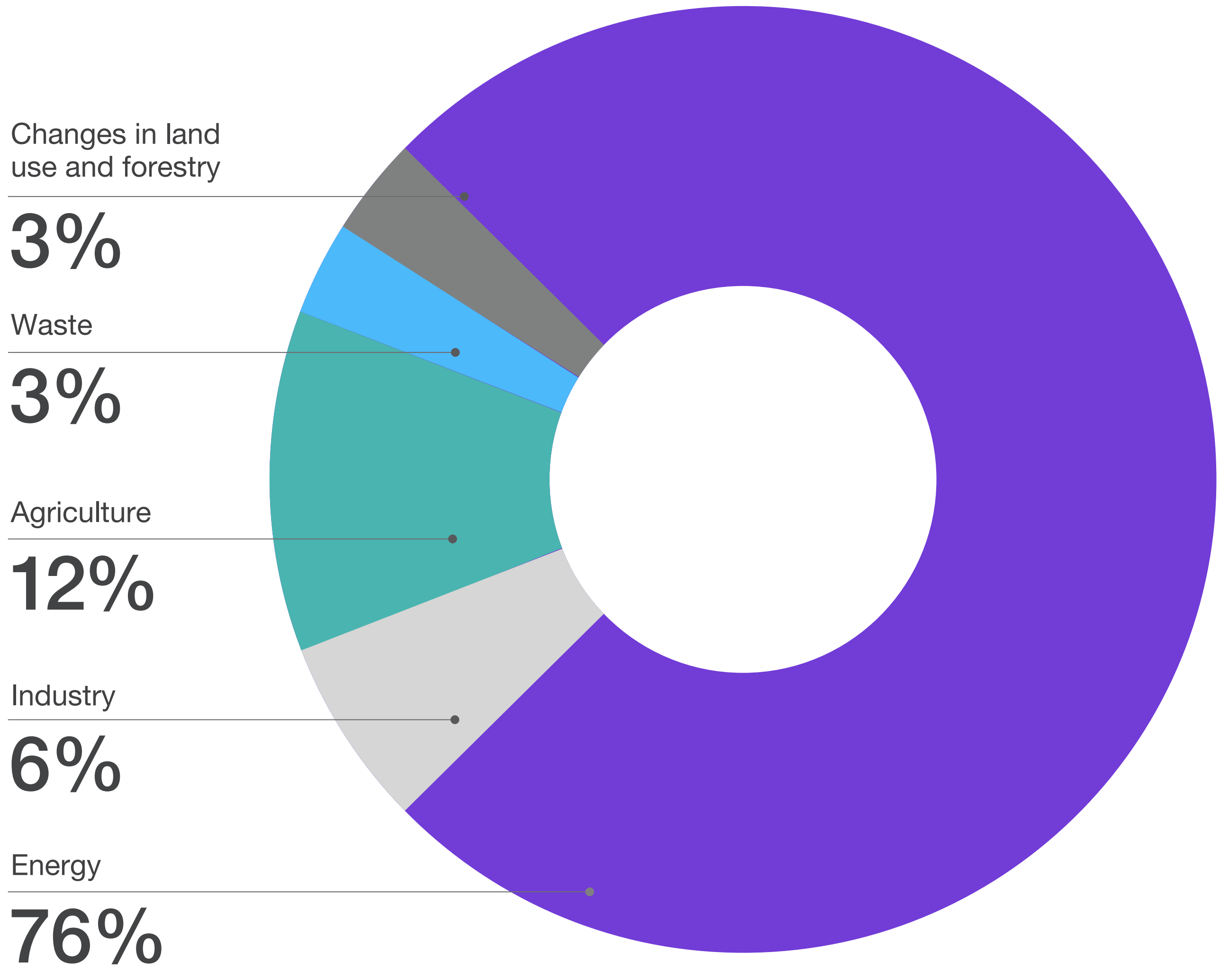
Energy and emissions - Global

The energy sector is responsible for 76% of GHG emissions worldwide, and accounts for the emissions related to burning fuels for different uses (transportation, households, and industry) and fugitive emissions[2].
The industrial sector includes the emissions generated as a result of the reaction between raw materials employed in industrial processes, and has grown to 6%.

2 Fugitive emissions are related to fuel extraction, processing, storage, and transportation to its final use.

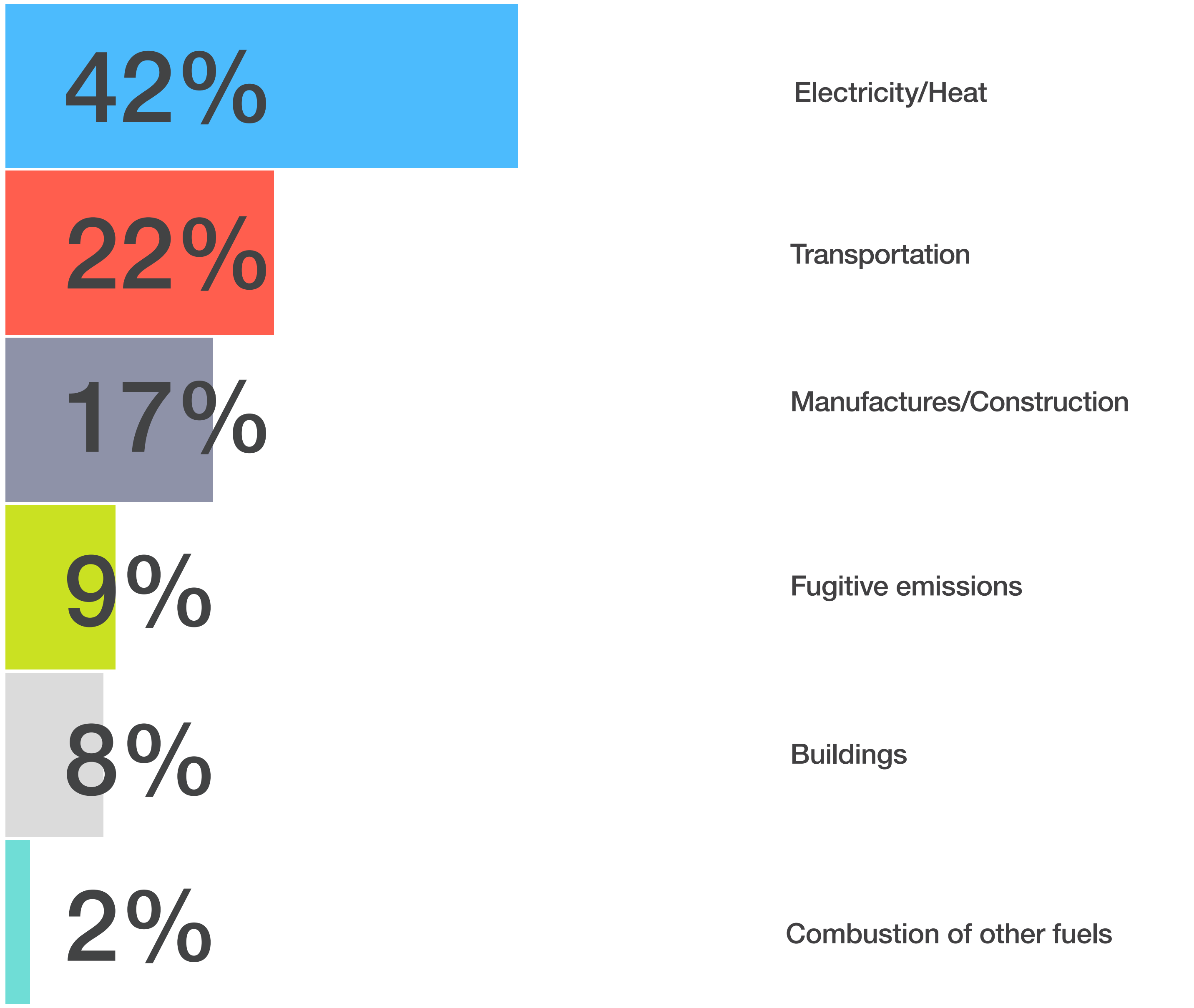
Development of the concept of just energy transition
1 2 3 4
1 2 3

Graphic 2 A Greenhouse gases by sector, world total (2019)



Source: https://ourworldindata.org/ghg-emissions-by-sector.

Graphic 2 B ▸ Detail of the energy sector



Source: https://ourworldindata.org/ghg-emissions-by-sector.

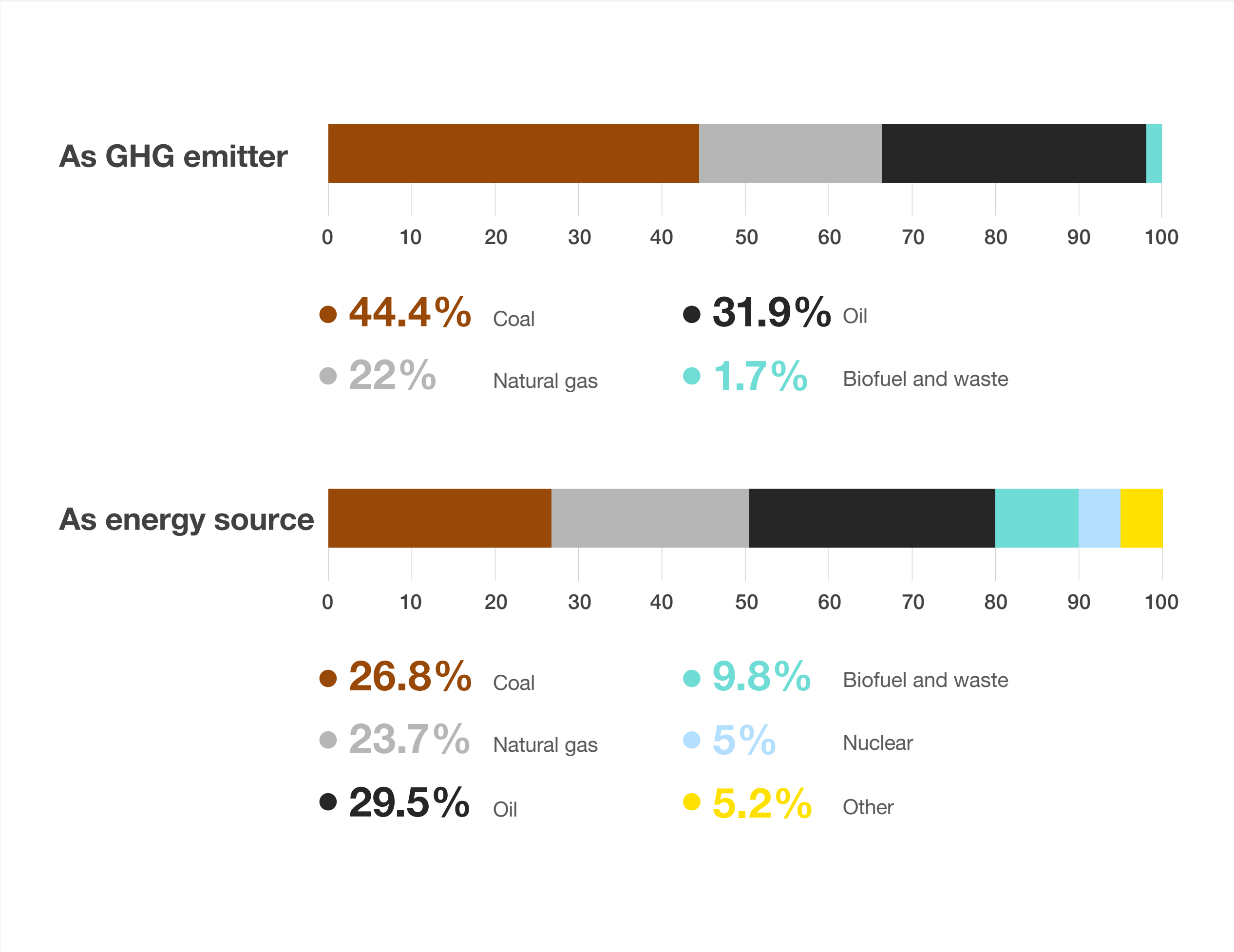
Development of the concept of just energy transition

The remnant (18 %) is related to land use (agriculture) and waste.

By comparing GHG emissions on a global basis and at energy sector level (76 % of the total), we can evaluate the weight of GHG emissions from fuel burning and extraction (energy sector) compared to total emissions.

- Coal: 35 % of total emissions (44.4 % of the energy sector).
- Natural gas: 17 % of total emissions (22.0 % of the energy sector).
- Oil: 25 % of total emissions (31.9 % of the energy sector).

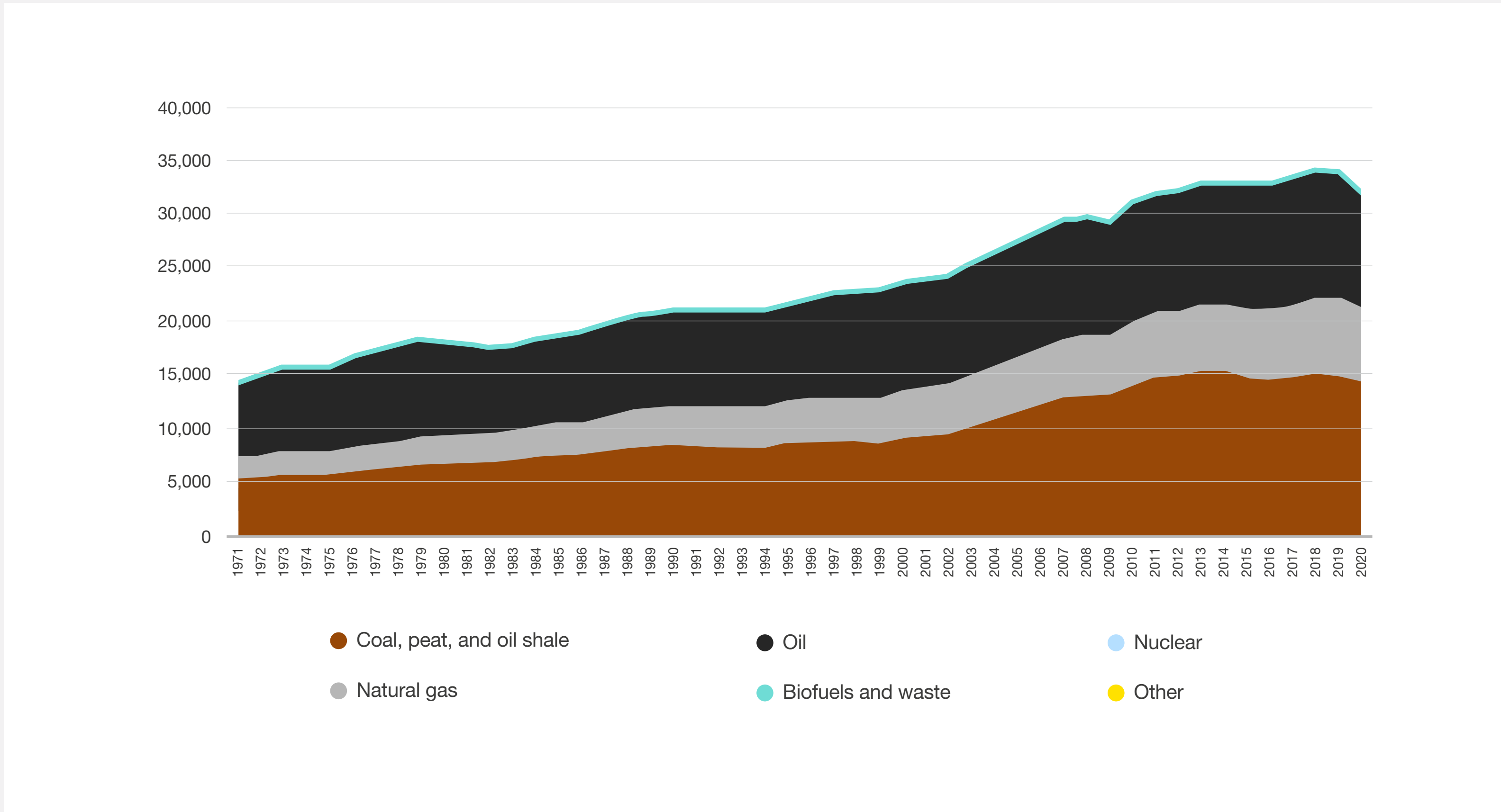
Graphic 3 ▶ Greenhouse gases and consumption by source, energy sector, 2019 (%)



Source: Own preparation based on data from the IEA.

Graphic 4 shows GHG emissions in the world classified by source. These shares have remained stable in the last 20 years.

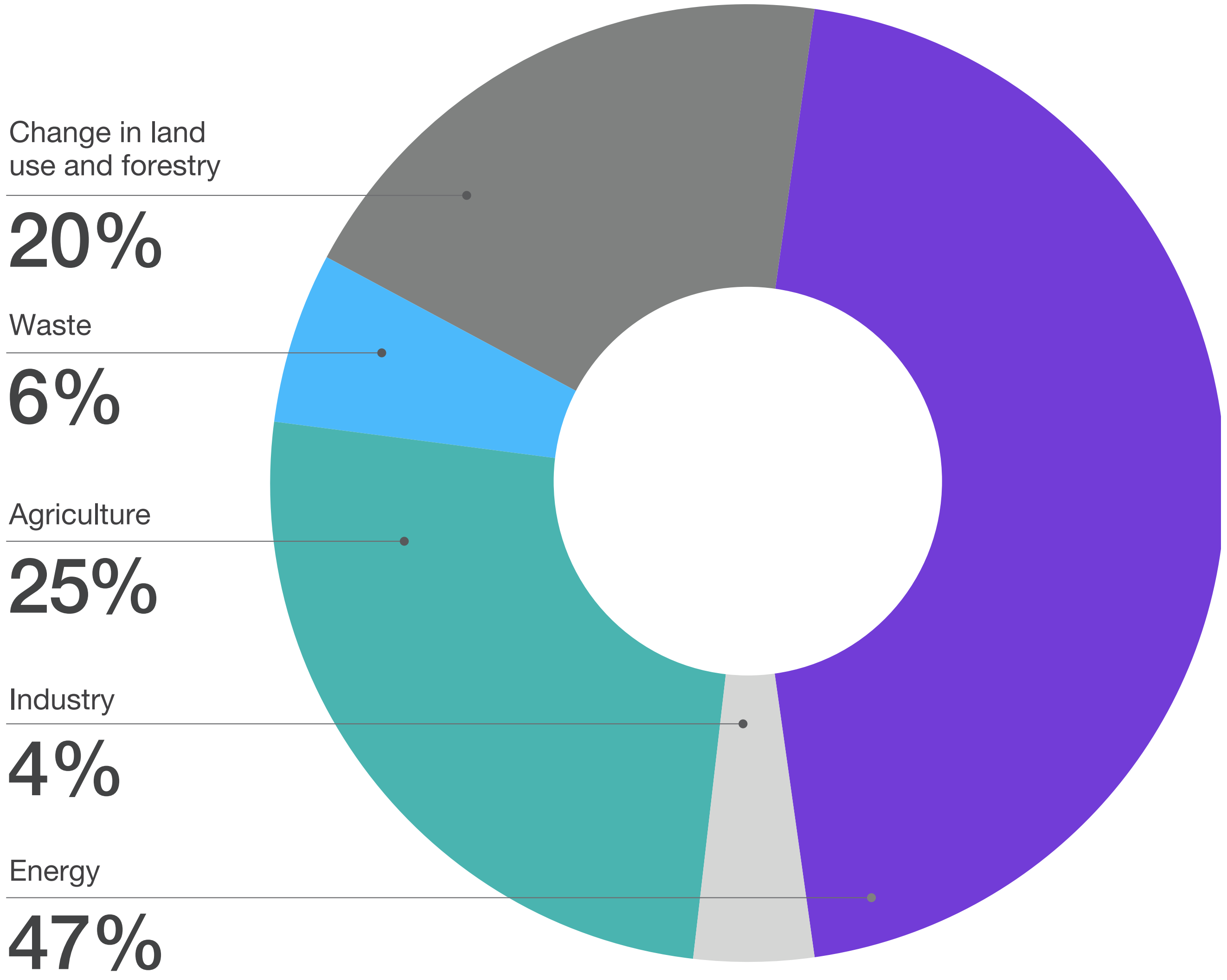
Graphic 4 ▶ Greenhouse gases from the energy sector (tCO_2)



Source: IEA.

In the LAC region, the shares of emissions by sector and source are different.

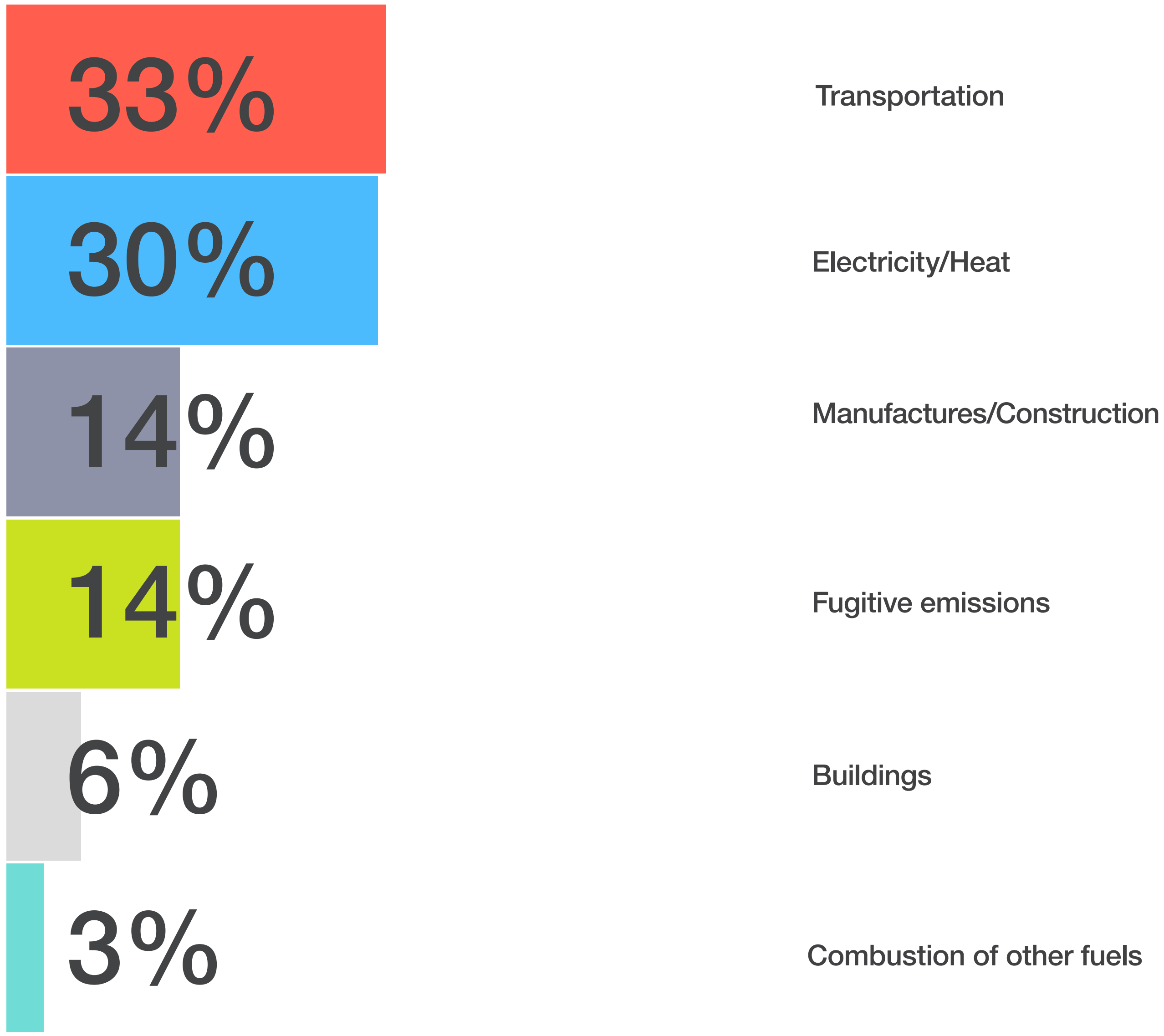
Graphic 5 A ▶ Greenhouse gases by sector in LAC (2019)



Source: Own preparation based on data from https://ourworldindata.org/ghg-emissions-by-sector.

Development of the concept of just energy transition
1 2 3 4
1 2 3

Graphic 5 B ▶ Detail of the energy sector



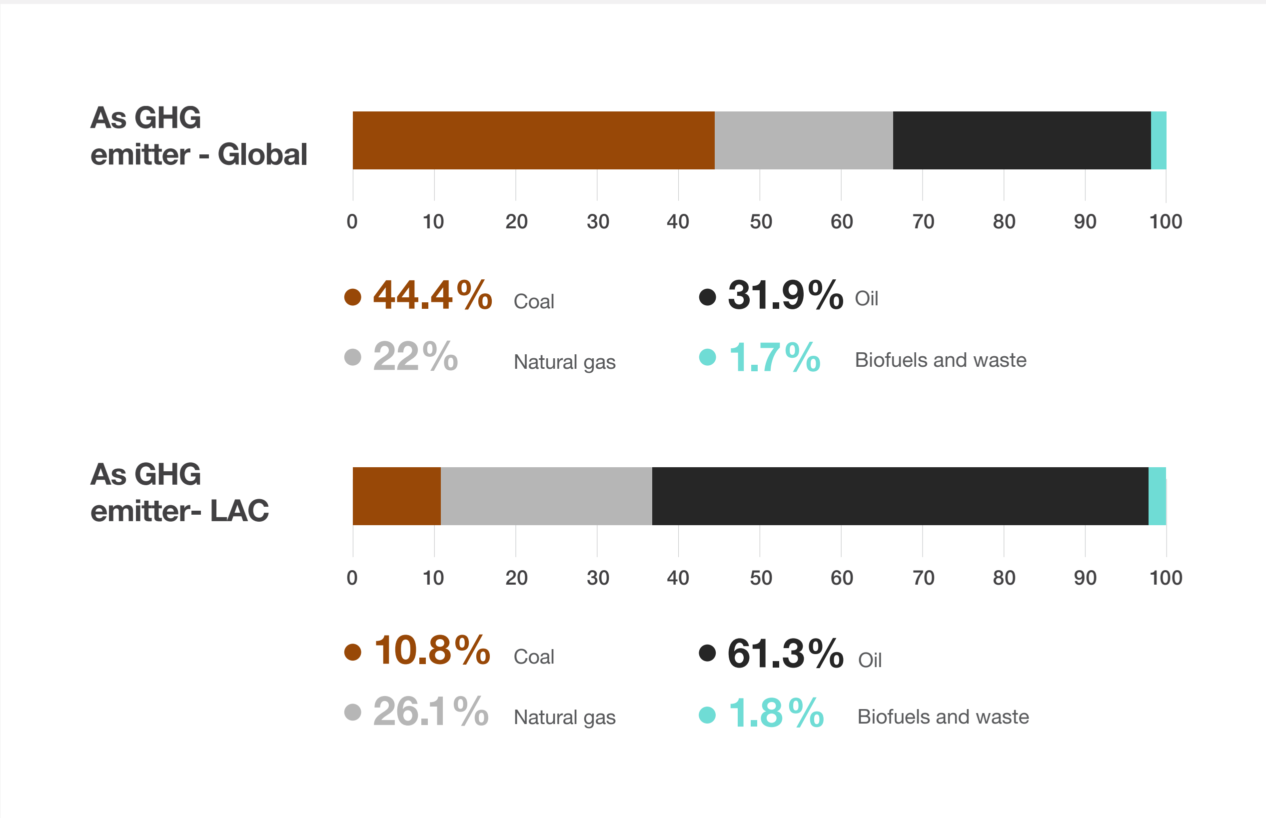
Source: Own preparation based on data from https://ourworldindata.org/ghg-emissions-by-sector.

Energy and emissions - LAC

Energy, with its different uses (transportation, households, and industry) is responsible for 47 % of GHG emissions in Latin America and the Caribbean. Agriculture and changes in land use account for 45 % of GHG in the region.

As to sources, and compared to 2019, we can see very low use of the more polluting energy in LAC, with only 10.8 % penetration of emissions caused by coal. Thus, we can establish that energy use in LAC has lower emissions than in the rest of the world on account of its energy matrix with more gas penetration and less coal penetration. Graphic 6 shows the gases in the energy sector by consumption source in LAC and in the world.

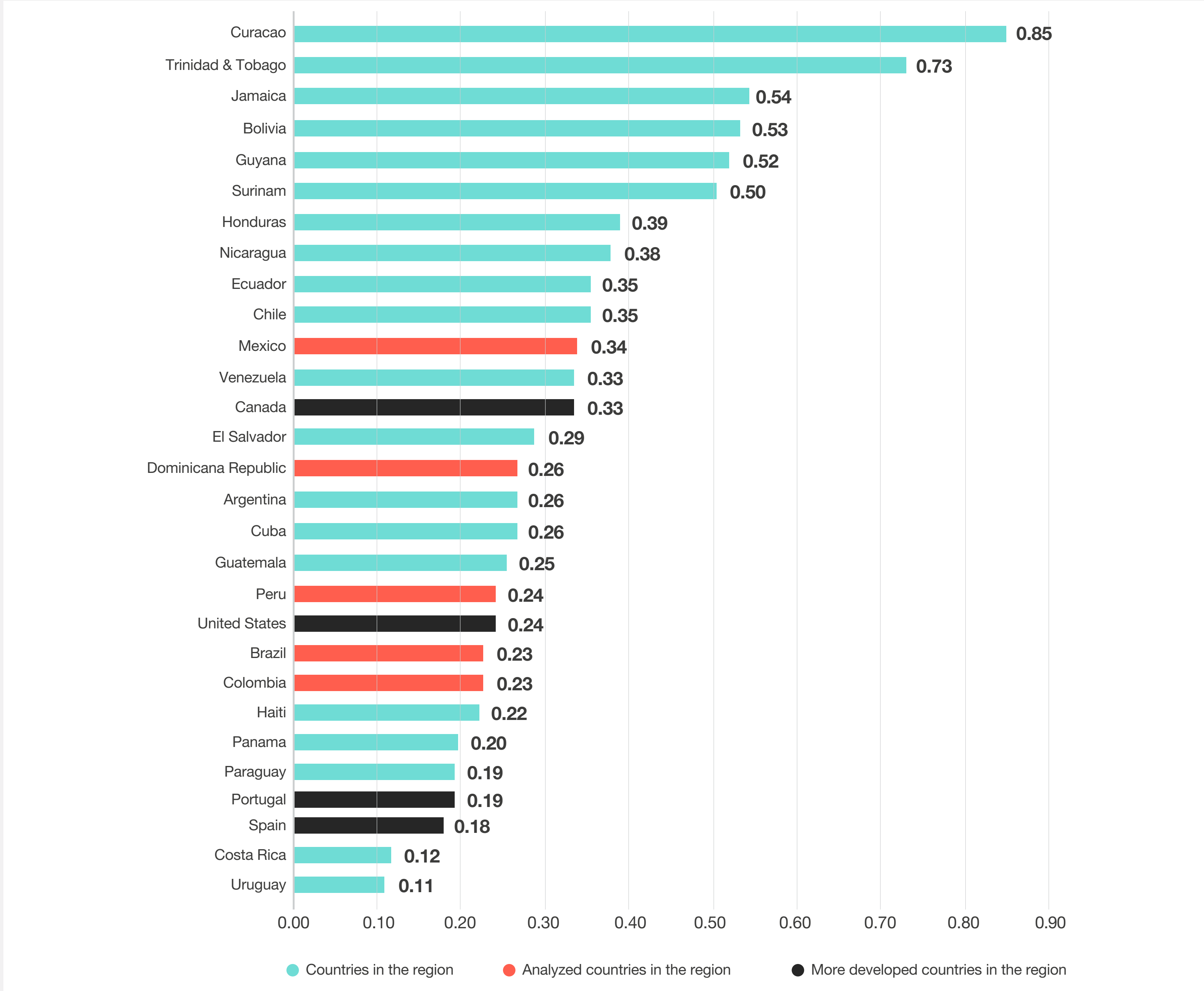
Graphic 6 Greenhouse gases from the energy sector by source, global versus LAC, 2019 (%)



Source: Own preparation based on data from the IEA.

Graphic 7 shows emissions with respect to the GDP of the countries in the region, compared to developed countries (in black).

Graphic 7 Greenhouse gases with respect to GDP, 2019 (kgCO2e/thousands of USD)



Source: IEA. Note: GDP valued at PPP. The five analyzed countries are represented in red.

The global average amounts to 0.39 kgCO_2e/thousands of USD. Table 2 shows the emissions of the sampled countries compared to some European countries and the world.

Table 2 Share of emissions by source (2019)

Energy sources	Brazil	Colombia	Mexico	Peru	Dominican Republic	Spain	Portugal	World
Coal	14%	24%	10%	5%	7%	8%	11%	44%
Oil	66%	54%	57%	60%	81%	60%	58%	32%
Natural gas	16%	21%	32%	33%	11%	30%	27%	22%
Others	3%	2%	1%	2%	1%	2%	3%	2%

Source: Own preparation based on data from IEA.

The energy matrixes of the countries in the region are intrinsically cleaner than the global average and, in general, they are in line with the matrix of developed countries. However, when compared to product unit, the countries in the region have higher emissions. This is due to the low development of the services sector.

Energy transition and equity

Over the last 300 years, there have been four energy transitions: from firewood to coal; from coal to oil and petroleum products; the introduction of natural gas, which replaced coal and some petroleum products; and the current energy transition from hydrocarbons to renewable energy.

None of these transitions required suspending the use of the dominant fuel in the previous stage; therefore, these transitions allowed for the depreciation of the assets in the value chains replaced, from their extraction to their use. The eventual replacement in these transitions occurred due to the competitiveness of the new source. Instead, the new transition arises as a result of international commitments to limit global warming and avoid the negative consequences of climate change, and must be carried out fast.

However, as long as new assets are not incorporated, the terms considered for this transition (30 years or more) may allow for the retirement of the existing assets and minimize the costs related to sunk assets.

Anyway, there is an intervention that consists in avoiding the incorporation of new assets with high emissions, which are currently competitive, during this time window. Nevertheless, the process of phasing out the existing ones can be managed.

This energy transition introduces a **dilemma between short-term needs (growth required to reduce poverty) and long-term ones (environmental protection)**. Poverty reduction in developing countries requires that the regulations to foster the energy transition allow for the recovery of the capital already invested in the activities that generate emissions while they remain competitive.

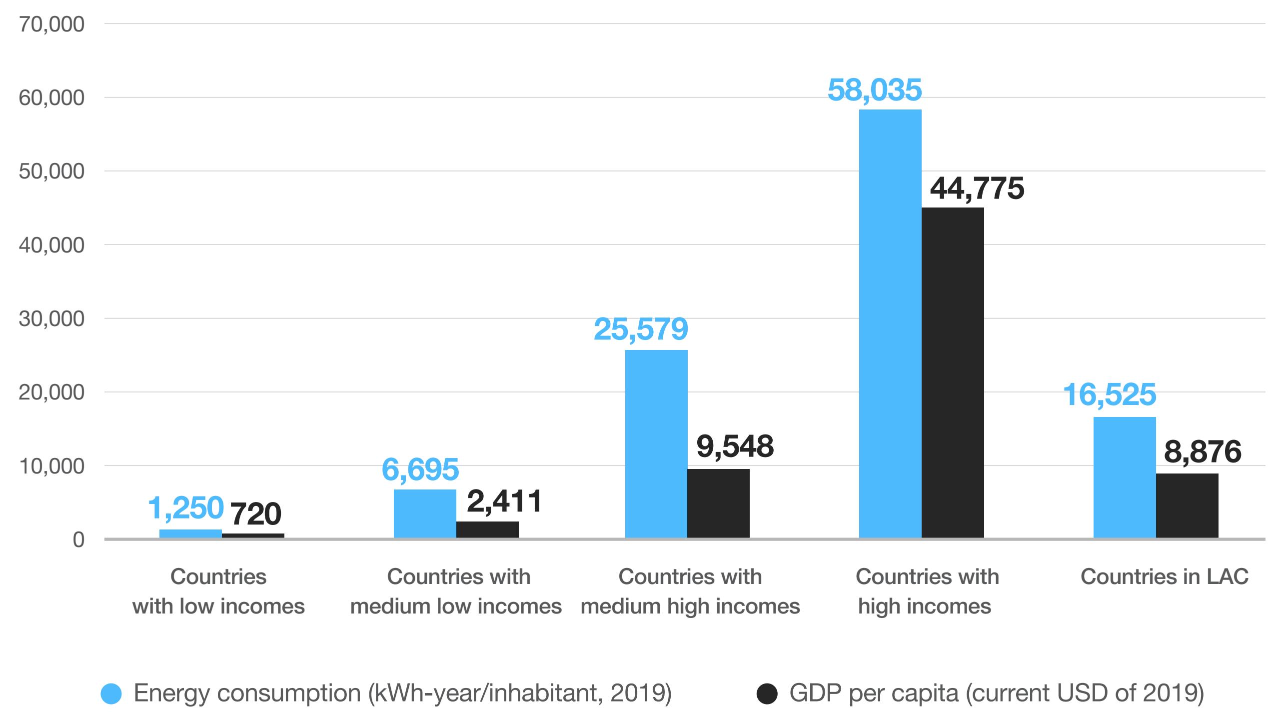
Such dilemma is captured in the Paris Agreement, since energy is a fundamental factor for economic development; therefore, it is expected that countries with lower incomes will increase their consumption and emissions – total and per capita – as indicated in Article 4 of the Paris Agreement:

> […] 1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.

Therefore, eradicating poverty, maximizing economic growth, and making them equitable are intrinsic conditions of a just energy transition process. In turn, energy transition plans and policies must consider meeting zero-emission goals in the second half of the century in order to reach a decent level of wellbeing in the context of the Paris Agreement goals. These gaps are observed in the differences in energy use per capita between the countries in Annex I and non-Annex I.

Energy use per capita is very different in the different country groups (see Graphic 7). The countries with higher incomes consume 46 times more energy than those with lower incomes.

Graphic 8 Total energy consumption per capita (kWh-year per capita) and GDP per capita (current USD of 2019 per capita)



Source: Own preparation based on data from Our World in Data and the World Bank.

The starting point in LAC and the analyzed countries

The transition in the energy sector in Latin America and the Caribbean

The LAC region is different from Europe and North America in the following aspects:

- Europe and North America have depreciated a large portion of their coal-fired generation; therefore, its replacement has no effects on the recovery of the invested capital. This situation is different in LAC, where investment in coal-fired plants was made between 2010 and 2020 (Dominican Republic, Guatemala, Chile, and Colombia). Early replacement would imply a cost to the company in terms of early asset depreciation;
- Hydroelectric power and biomass are an important part of energy supply in LAC;
- Hydro power is an energy resource with high penetration in the power sector in the region. There is still hydro development potential;
- LAC is undergoing a transformation period, independent of the energy transition, starting with the simultaneous growth in the use of gas (conventional and non-conventional) and in new renewable energy. There are dissimilar reserves of renewable and non-renewable energy resources among the countries in the region, which generates complex and dynamic dependences between them, with interactions between geopolitical and energy areas on different scales.

Development of the concept of just energy transition

- The development of shale gas in Argentina and of the oil and associated gas reserves in Presal, the current exploitation of (non-associated) natural gas reserves in Venezuela, and of natural gas reserves in Peru (Camisea) enable the region to gain access to cleaner resources. The importance of natural gas has increased. It accounted for 31 % of the total primary energy supply in the region in 2020, according to data from the sieLAC (Energy Information System for Latin America and the Caribbean). Should its current development continue, gas would replace hydro power as the main source of power generation in LAC by 2030, according to the analysis of the United Nations Environment Programme (UNEP). Substituting coal and oil with natural gas implies a significant emission reduction process at a sufficiently gradual pace to allow several countries in the region to maintain low prices and high energy security levels.

Energy resources in the region

It is important to mention that LAC, and particularly Brazil, Colombia, and Peru, have total energy matrixes with high penetration of renewable energy. The use of biomass stands out in almost all the sectors, especially in the industrial, residential, and transportation (biofuels) sectors. When analyzing the power sector in more detail, the important development of hydro power and, more recently, solar and wind generation, gives the region a good score in terms of the sustainability and carbon intensity of its systems.

Table 3 shows the penetration of these types of energy in the analyzed countries.

Table 3 Share of energy sources in each country (2019)

Country	Coal	Natural gas	Oil	Hydro	Nuclear	Firewood	Sugar cane and by-products	Other primary sources
Brazil	5.2%	12.8%	32.0%	12.2%	1.5%	9.2%	19.0%	8.1%
Colombia	12.9%	22.7%	41.3%	11.9%	0.0%	5.3%	4.5%	1.4%
Mexico	8.1%	58.3%	22.8%	1.4%	2.0%	4.0%	1.8%	1.7%
Peru	2.5%	30.6%	41.9%	12.7%	0.0%	8.8%	2.1%	1.5%
Dominican Republic	12.7%	27.7%	30.1%	2.5%	0.0%	14.4%	8.1%	4.5%

Source: sieLAC. Note: "Other primary sources" includes non-conventional renewable sources.

The countries in the region have solar, wind, and hydroelectric resources. Of the countries studied in this report, Brazil, Colombia, and Mexico have hydrocarbon resources whereas Brazil, Mexico[3] and Peru have natural gas reserves.

3 At present, Mexico is not exploiting its shale gas reserves and depends on imports from the United States.

"The LAC region possesses abundant solar, wind, hydroelectric, and biomass resources, contributing to its sustainability profile and low carbon intensity"

2. The concept of energy transition according to the different countries and some major players

Compilation of ideas and definitions of energy transition

This section compiles documents on climate change, the energy transition, and its definitions by international institutions, in order to synthesize a conceptual definition.

Paris Agreement – Energy transition components

In the United Nations Conference on Climate Change (COP21), conducted in Paris in December 2015, long-term goals were agreed on, defining the following aspects of climate change and energy transition as the main tool to reduce its effects.

Development of the concept of just energy transition

- Long-term objective as regards temperature (Article 2): to **limit the increase in global temperature to well below 2 °C**, while continuing efforts to limit it to 1.5 °C.
- Peak and climate neutrality (Article 4): The countries aimed **to reach global peaking of greenhouse gas (GHG) emissions as soon as possible and to recognize that peaking will take longer for developing country Parties** to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHG in the second half of the century.
- Mitigation (Article 4): **It establishes binding commitments from all the Parties to prepare, communicate, and maintain a certain nationally determined contribution (NDC)**, and apply measures on a national basis to meet such commitments. In their NDCs, the countries communicate the measures that will be taken both to reduce their GHG emissions to allow them to meet the Paris Agreement objectives and to develop the necessary resilience to adapt to the impact of temperature increase.
- **Adaptation** (Article 7): A commitment is made to enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change, with a view to contributing to sustainable development and providing an adequate adaptation response in the context of the temperature-related goal referred to in Article 2.
- **Financing** (Article 9): It establishes the need for developed countries to financially support developing countries. For this purpose, the Agreement requires an increase in this financing.

Definition of the United Nations Development Programme

For the sake of simple communication on its website, the United Nations Development Programme (UNDP) defines “the energy transition is a continuing process requiring long-term energy strategies and planning, with a country-tailored focus on applying appropriate energy technologies to reach net zero emissions” (UNDP, 2023).

Definition of the International Monetary Fund

The International Monetary Fund (IMF) analyzes the transition in terms of its economic impact.

In its World *Economic Outlook*, October 2022, the IMF[4] presents the topic of the transition to a net zero society through the evaluation of its impact on the economy. According to this study, an immediate implementation of gradually applied climate change policies will bring about a lower total cost. The energy transition will reduce economic growth and increase inflation in the short term; however, postponing the implementation of the measures will multiply such cost.

The IMF makes different hypotheses on the speed of the power generation transition towards low carbon emission technologies and places such costs at between 0.1 and 0.4 additional percentage points of inflation per year.

4 World Economic Outlook (International Monetary Fund) October 2022.

Such impact occurs due to the adoption of technologies whose levelized costs are not the lowest and to the dismantling of facilities before the end of their economic and financial lives. This means that, if the appropriate measures are immediately applied and gradually introduced in the next eight years so that the emissions goal is met, by the end of the decade there will be 25 % less greenhouse gases than in 2022.

Definition of the International Energy Agency

The International Energy Agency (IEA)[5] especially mentions the short-term situation originating in the Russian invasion of Ukraine. This invasion has caused a global energy crisis that has forced the countries that are most dependent on Russian gas to take short-term measures. Many of them have concomitantly taken longer term measures to increase or diversify their oil and gas supply and accelerate structural change.

The IEA shows energy transition as the opportunity to build a safer and more sustainable energy system, and proposes the following guidelines to help reinforce energy security in the “medium transition”.

- **Prioritize energy efficiency and behavior changes.** The energy crisis highlights the crucial role of energy efficiency and the behavioral measures required to help avoid mismatches between supply and demand.
- **Reverse the tendency towards energy poverty** and facilitate the mobility of lower income communities towards the new energy economy. In emerging and developing market economies, the people with lower incomes consume nine times less energy than those with higher incomes, but spend much more on energy in proportion to their income.

5 World Energy Outlook 2022, IEA, November 2022.

- **Synchronize the penetration of clean energy technologies with the phase-out of investment in fossil fuels.** Cutting down on investment in fossil fuels before increasing investment in clean energy promotes a rise in prices and does not necessarily foster safe transitions.
- **Collaborate to reduce the cost of capital in emerging and developing markets.**
- **Manage the retirement and reuse of the existing infrastructure carefully.** Part of the existing fossil fuel infrastructure performs functions that will continue being critical for some time, and its early retirement may have negative consequences on energy security.
- **Gradually eliminate subsidies for fossil fuels.** Carbon pricing and other market reforms can guarantee adequate price signals.
- **Address the specific risks that production economies face. Diversification will be crucial to mitigate risk.** Some countries are investing a part of the current windfall revenues from oil and gas in low-emission renewable energy and hydrogen.
- **Invest in flexibility: a new guideline for electric security. The increasing variability in power supply and demand means that the flexibility requirement will have grown fourfold by the middle of the century.** Battery storage and an enhancement of demand-side response are becoming more and more important.
- **Guarantee diverse and resilient clean energy supply chains. Foster climate resilience of energy infrastructure.**
- **Provide strategic direction and address market failures without dismantling markets.** Governments should make a first move to ensure safe energy transitions, address market distortions, particularly subsidies to fossil fuels, and correct market failures. 70 % of the investment required for the transition should come from private sources.

Definition of the International Renewable Energy Agency

The International Renewable Energy Agency (IRENA[6]) mentions that the need for an energy transition has become more urgent. Aggravating crises underscore the compelling need to accelerate the global energy transition and governments should assume the challenging task of addressing apparently opposite agendas on energy security, resilience, and affordable energy for all.

The acceleration of the energy transition is also essential for long-term energy security, price stability, and national resilience. This pathway would also create jobs, reduce poverty, and promote the cause of an inclusive and climate-safe global economy.

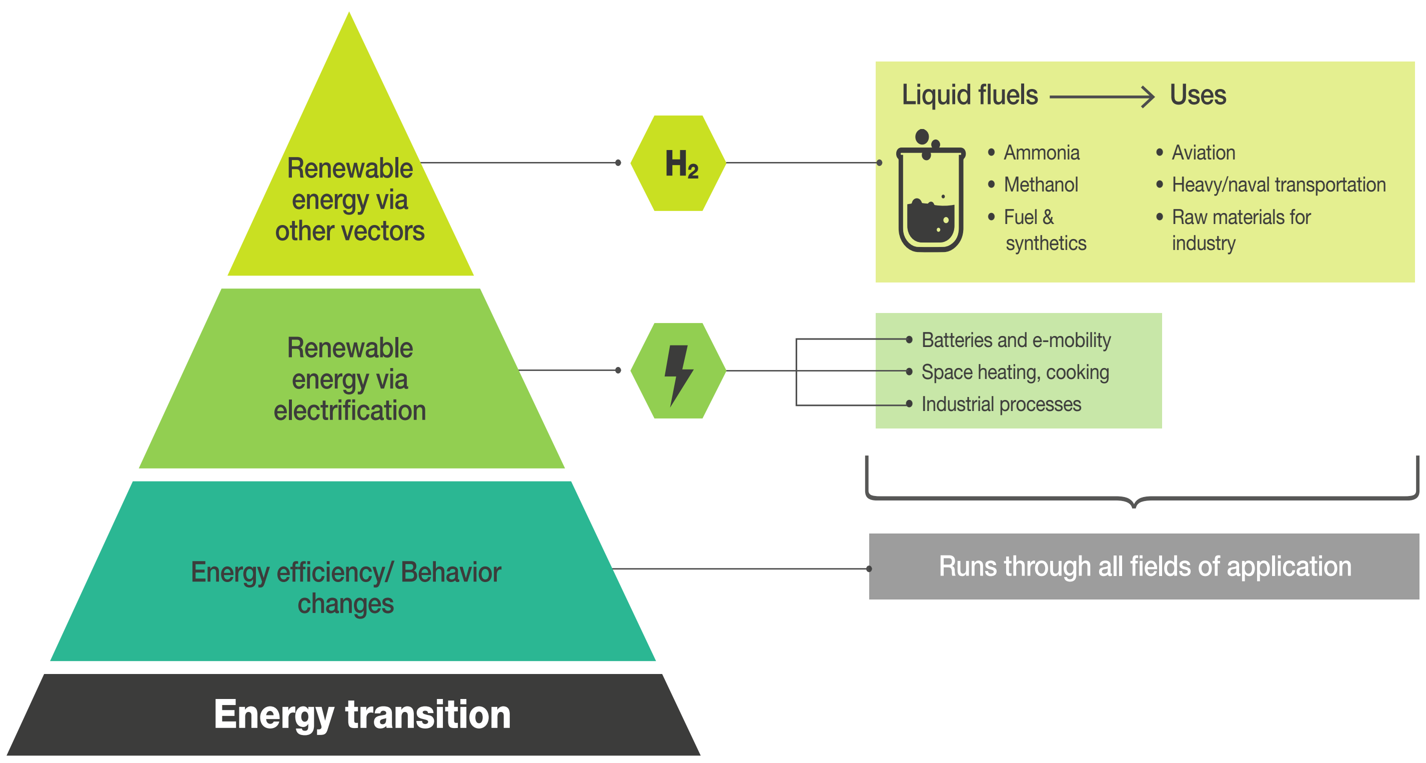
IRENA's 1.5 °C pathway places electrification and efficiency as key drivers of energy transition, facilitated by renewable energy, low-emission hydrogen, and sustainable biomass. The pathway, which requires a huge change in the way societies produce and consume energy, may be achieved through:

- significant generation growth and direct use of electricity based on renewable energy;
- substantial enhancement of energy efficiency;
- electrification of end-use sectors (e.g., electric vehicles and heat pumps);
- low-emission hydrogen and its derivatives;
- bioenergy with carbon capture and storage in the place where it is produced.

6 IRENA (2022), *World Energy Transitions Outlook 2022: 1.5 °C Pathway*, International Renewable Energy Agency, Abu Dhabi.

Graphic 9 summarizes the main pathways to energy transition.

Graphic 9 Pathways to energy transition



Source: Own preparation.

Definition of the World Bank

The World Bank emphasizes the importance of the energy sector as a driver of investment, innovation, job creation, and nations' growth. In this context, it focuses on reducing inequality in the sector. It mentions that, as of this date, 733 million people still have no access to electricity and 2,600 million cook with polluting fuels that are harmful to their health.

The COVID-19 crisis and the Ukraine war have generated a strong rise in energy prices, increasing shortage situations and concerns about energy security. These consequences have affected almost all countries although, in the World Bank's view, developing countries have been the most affected. An example is that around 90 million people in Asia and Africa who had gained access to electricity can no longer afford the expenses associated with covering their basic needs.

In this context, the World Bank identified renewable technologies as a great opportunity to mitigate climate change, generate resilience in view of price volatility, and reduce the cost of energy. Based on what has been said, it focuses on addressing the issue of energy accessibility, particularly in lower-income countries characterized by fragility, conflict, and violence.

Some of its lines of work are

- foster renewable generation;
- support a reduction in the use of coal;
- reduce methane emissions;
- increase energy accessibility;

- reduce the impact on health of traditional fuels in cooking activities;
- promote emission pricing mechanisms;
- foster energy efficiency.

Other concepts associated with the just energy transition

In addition to the concepts that include energy transition, several concepts of just energy transition have been proposed.

The International Labor Organization (ILO) has defined just transition as “greening the economy in a way that is as just and inclusive as possible to everyone concerned, creating decent job opportunities and leaving no one behind”.

The Intergovernmental Panel on Climate Change (IPCC) defined 11 elements for a just transition:

1. investment in establishing low-emission and labor-intensive technologies and sectors;
2. research and early assessment of the social and labor impact of climate policies;
3. social dialog and democratic consultation of social interlocutors and stakeholders;
4. creation of decent jobs, active policies related to labor markets and labor rights;
5. equity in energy access and use;
6. economic diversification based on low-carbon investment;

7. training programs and realistic reforms leading to decent jobs;
8. specific gender policies that promote equitable results;
9. promotion of international cooperation and coordinated multilateral actions;
10. reparation of past damages and injustice;
11. consideration of intergenerational justice issues, such as the impact of political decisions on future generations.

Organization of the main elements of energy transition by topic

The energy transition towards a low-carbon economy is associated with significant changes in the primary energy matrix and production infrastructure, transportation, and use of energy resources. Among them, we can point out the **incorporation of renewable primary sources on the supply side** and the combination of **consumption electrification/energy efficiency on the demand side**. Different lines of action are defined in the analyzed documents.

Non-conventional renewable energy

- **Emission mitigation.** Renewable energy, such as solar, wind, hydro power, and geothermal, generate electricity without producing significant emissions of carbon dioxide or other greenhouse gases. This directly contributes to mitigating climate change and reducing dependence on highly polluting fossil fuels.
- **Diversification of the electricity matrix.** Non-conventional renewable energy allows diversifying power generation, which reduces vulnerability to droughts in countries that are highly dependent on hydro generation, and to fuel price volatility in countries with a more thermal electricity matrix.
- **National and potential resources.** The countries in the region largely benefit from high solar and wind production factors as well as, in certain cases, geothermal and biomass potential.
- **Competitive levelized costs of energy.** In recent years, both solar and wind technologies have experienced a considerable reduction in their capital expenditures (CAPEX) and have gained competitiveness against other technologies that produce electricity. The trend is expected to continue in the future thanks to continuing enhancements in technological processes, the economies of scale in component manufacture, and greater market competition with the global development of these technologies.

Development of the concept of just energy transition

Energy efficiency

- **Enhancement of energy efficiency in residential, commercial, industrial, etc. consumption.** The implementation of energy efficiency (EE) actions in the region has resulted in the enhancement of energy intensity, but a lot of work is still pending. Energy efficiency, together with behavior changes, is one of the pillars of energy transition.

Grid decentralization

- **Introduction of renewable energy and distributed generation associated with technological innovation in grids.** The technological outlook is also rapidly changing on the demand side and in the grids. Optical fiber grids, cellular phones, and digital solutions collectively offer a growing number of options to monitor, control, and optimize consumption, auto-generation, and electricity storage while the implementation of a smart transmission system offers a solution to renewable source variability.
- **Distributed generation, energy services companies, and response to the demand.** The implementation of distributed generation (DG) implies designing new business models and changing the use of (transmission and distribution) grids. The decision to invest in DG is much more decentralized.
- **Electric mobility also constitutes a change in the power sector** that significantly increases the demand for electricity and offers new flexibility sources to the system by contributing vehicle batteries as reserve mechanisms for household consumption.

Natural gas

- **Mitigation of emissions.** Natural gas is the fuel with the least CO_2 emissions at the combustion stage compared to other energy sources based on fossil fuels (see IPCC[7]). On the other hand, natural gas combustion provides an enhancement of air quality, as it reduces nitrogen oxide emissions by 80 % and practically eliminates particulate matter and sulfur oxide emissions, compared to other fossil fuels (CAF, 2022)[8].
- **Gas in the global energy transition.** In its 2022 publications, the International Energy Agency (IEA) indicates that natural gas will continue being a source of energy and will be used in power generation with carbon retention systems.
- **The use of gas in electric power production.** Latin America is undergoing a period of transformation generated by the simultaneous growth in the use of (conventional and non-conventional) gas and new renewable energy (wind and solar). In addition, the importance of gas as a stability factor for interconnected systems should be pointed out, particularly in the case of demand or electricity production with high seasonality. Moreover, gas can offer firmness to the system in the event of droughts in highly hydroelectrical systems.
- **Resources in the region.** There are dissimilar reserves of renewable and non-renewable energy resources in the different countries, which generates a complex and dynamic dependence between them, with interactions between geopolitical and energy areas on different scales. The development of shale gas in Argentina and the oil and associated gas reserves in Presal allow the region to gain access to cleaner resources. The importance of natural gas has been growing. It accounted for 31 % of total primary energy supply in the region in 2020, according to data from the sieLAC (Energy Information System for Latin America and the Caribbean).

7 https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf
8 https://scioteca.caf.com/handle/123456789/1980

Development of the concept of just energy transition

- **The development of hydrocarbon sources in Latin America.** The United Nations Environment Programme (UNEP), in a document on gas in Latin America (Quirós-Tortós et al., 2022), mentions that Mexico, Brazil, and Argentina are increasing their investments in and exploitation of fossil fuels, particularly natural gas, while many other countries are planning new natural gas infrastructure projects.
- **Gas as an alternative in sectors that are difficult to electrify.** In industry, gas may have a favorable performance due to its lower environmental impact compared to coal and to the fact that its price may be lower than that of oil, especially in processes requiring high-temperature heat (AIE[10]).
- In this context, natural gas may be a legitimate CO_2 emission mitigator with a relevant role, particularly for industrial uses with difficult electrification, as well as a source to produce firm electric power.

The importance of gas as a stabilizing factor for interconnected systems should be emphasized, particularly in the face of highly seasonal electricity demand or production. Additionally, from an economic perspective, gas represents a technologically and financially viable solution until the maturity and optimal financing cost of other technologies are reached.

9 *United Nations Environment Programme (2022). Is Natural Gas a Good Investment for Latin America and the Caribbean? From Economic to Employment and Climate Impacts of the Power Sector.*
10 https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions

Transportation

- **Mitigation of transportation emissions and transition alternatives.** The transportation sector is the second sector with the largest number of emissions in the world. It is in the transportation market that we can best observe the concurrence of several value chains to solve the emissions of different subsectors.
  - Electric mobility is mainly focused on solving the issues of small and medium-sized vehicles as well as trucks for medium distances. There is also some progress regarding electric long-distance road haulage.
  - Hydrogen and its derivatives focus on heavy long-distance haulage (truck tractors, maritime, and aviation).
  - Natural gas may be a transition option for trucks and truck tractors, but its impact in terms of emission reduction is not significant.
  - Green fuels (biofuels) and synthetic fuels (H_2 derivatives) are a transition option for aviation.

  It is in the freight transportation and aviation sectors where more technological development efforts are required. Hydrogen for aviation is a proposal with little specific progress in its development towards competitive prices.

Energy Storage

- **Latin America has abundant hydroelectric resources and the potential to continue its development.** Projects with reservoirs can be a feasible alternative while the value chains for batteries and low-emission hydrogen are developed.

- **The introduction of green hydrogen.** Electricity generated from renewable sources can be used to produce hydrogen, which is an excellent energy storer and can be used in transportation. Hydrogen can become a key piece to achieve the necessary flexibility in the power system by using renewable energy[11], as well as in transportation logistics.
- One aspect that is not much mentioned in the analyzed documents is that hydrogen and synthetic fuels from hydrogen are technologies that have already been developed but are still not competitive. They can be transported long distances from regions with abundant energy resources to very distant cities. In addition, synthetic fuels would reduce the number of sunk assets in the sectors associated with the value chains in the vehicle and biofuel sectors[12].

Emission reduction

- **Carbon capture.** The objective of eliminating net carbon emissions completely in less than 30 years will require universal changes both in global industrialized processes and in domestic energy consumption practices. There is a less publicized, but equally important strategy which is CO2 capture at the source or directly from the atmosphere (carbon capture). The technologies used are affected by their high cost and mainly by storage. The latter is the technological factor that has not been developed yet. Currently, only 0.1 % of CO_2 global emissions is captured. This percentage is expected to grow to 19 % by 2050. Research initiatives focusing on carbon capture technology have increased in recent years but, to date, few applications have been commercially implemented.

11 It should be explained, however, that its low density at ambient temperature (0.09 kg/m³) makes the H_2 energy content per volume unit around 3,500 times lower than that of these fuels. This characteristic, in addition to its liquefaction point close to absolute zero (-253 °C), makes hydrogen storage costly and complex. Moreover, hydrogen may be an option for sectors that would otherwise be difficult or very expensive to decarbonize through electrification, such as energy uses in industrial processes and transportation.

12 Synthetic fuels enable the generation of synthetic gas and synthetic derivatives, which would allow us to use the existing plants for some additional time. Synthetic fuels release CO_2 in the combustion stage but absorb CO_2 from the atmosphere during biomass growth.

- Oceans and woodland are the oldest carbon capture and storage mechanism. Woodlands, as great carbon sinks, absorb atmospheric carbon and store it for centuries through photosynthesis. According to www.woodlandtrust.org.uk, “The entire woodland ecosystem plays a huge role in locking up carbon: the living wood, roots, leaves, deadwood surrounding soil and its associated vegetation”. Actions on these technologies are not part of this study. One woodland hectare absorbs around 400 tons of CO_2.

Carbon markets

Carbon prices expressed in carbon taxes help to accelerate the introduction of clean technologies. The World Bank (Partnership for Market Readiness, 2022), indicates:

> […] Carbon pricing is a cost-effective policy tool that governments and businesses can use as part of their broader climate strategy. It creates a financial incentive to mitigate emissions through price signaling.
>
> By incorporating the costs of climate change into economic decision-making, carbon pricing can help drive changes in production and consumption patterns, thereby supporting low-carbon growth.
>
> Carbon pricing policies can help remove price barriers that hinder low-carbon development. However, their effectiveness is limited if other policies that can reinforce and complement them in response to other climate change challenges and market failures are lacking.

- The pricing system is the most efficient mechanism to resolve incentives for carbon emissions; such mechanisms allow a simple scheme to communicate the costs associated with each technology.
- The problem is how to incorporate emissions to prices. Emission measurement starts with emission estimations based on the fuels and instruments used without accurately measuring the complete cycle. In the case of emissions related to primary production, this situation is very complex. These restrictions generally limit the possibility of imposing these taxes or price mechanisms.
- In LAC, discussions have dealt with the creation of Pigou-style carbon taxes. However, a deep discussion of these instruments should take place

in order to have measurement and pricing mechanisms in line with the particular situation of the region, where it is estimated that the greatest number of emissions originate in land use.

Regulatory framework and public policies

- The solutions proposed in the region for energy transformation will require an assessment of the following elements:
    - gradualness in the implementation of measures, in particular, it will be necessary to:
        - manage the retirement and reuse of the existing infrastructure with care;
        - synchronize the penetration of clean energy with the retirement of polluting energy;
        - provide strategic direction and address market failures without dismantling markets.
    - Implementation of competitive markets to strengthen the economic development of the region;
    - Power grid flexibility to enhance efficiency and reliability in variable electric resources management;
    - Promotion of distributed clean energy resources to progress towards universal access and resilience;
    - Integration of energy planning between sectors and at regional level to promote efficient use;
    - Strengthening of regulatory harmonization and market design to foster regional integration;
    - measures to address the activities that will be replaced due to the transition;

    - Implementation of green financing mechanisms;
    - tariffs that reflect costs.

Financing

- Financing is a key factor mentioned in the Paris Agreement and in the UNDP, IMF, and World Bank definitions. Article 9.1 of the Agreement states that greater efforts will be made to obtain financing from the countries in Annex I.

“LAC can use electricity from renewable sources to generate green hydrogen, which has potential to become a key piece in the regional power system and transportation”.

3. Conceptualization of the just energy transition in Latin America and the Caribbean

Two key aspects for the future development of this study are defined below: what the energy transition in LAC implies and the conceptualization of just energy transition for the region.

Some differential characteristics of LAC that must be evidenced in the energy transition

As indicated above, the region is characterized by:

- a change in land use as main emission source;
- low penetration of coal, both in the energy and the electric matrix;
- gradual penetration of natural gas;
- lower emissions per capita than in the rest of the world;

- higher emissions than those of developed countries, measured against GDP;
- no access to basic services for a portion of lower-income people;
- unequal distribution of wealth;
- mean energy consumption in most of the countries in the region;
- energy supply and demand growth perspectives for the period 2023-2050;
- primary energy supply with a high share of renewable energy[13] (power generation and biofuels);
- large reserves of renewable and fossil resources allowing for source diversification, particular to each country under analysis.

The region must take advantage of the abundant natural resources, such as solar and wind energy, hydro power (large projects that can still be built) and biofuels (from soybean, sugar, and others) along with gas developments as transition fuel to amortize the investment made in the last 20 years.

Moreover, the transition must be inclusive; therefore, any modification in price systems (subsidies) required by the IRENA and the IEA must be analyzed from a local perspective.

13 Since 2010, the countries in the region have promoted the introduction of non-competitive technologies in the power sector, socializing their higher costs through electricity prices in an environment of low energy prices. In addition, there have been contributions from climate funds or local development banks (BNDES, Corfo) for pilots in different segments of the value chain.At present, higher energy prices make us think that the region will develop non-competitive projects when promotion funds from the climate funds, international financial institutions or local development banks are available.

The just energy transition in Latin America and the Caribbean

The **just energy transition** is an energy system conversion process that seeks to **gradually reduce greenhouse gas emissions** by promoting the use of technologies that employ the resources available in the region, prioritizing those that contribute more to **economic growth** and are subject to reaching net zero emissions while maintaining the approach **of enhancing the standard of living** towards one that is compatible with a decent life. This concept is in line with the Paris Agreement, which establishes that developing countries will take longer to meet these goals and that the process should be based on equity and in the context of sustainable development and the efforts to eradicate poverty.

This transition implies accelerating the introduction of clean, economically competitive technologies and the enhancement of energy efficiency in the value chains of the energy sector.

Clean technologies are those that generate low or zero emissions (renewable energy, natural gas, nuclear, certifiable biomass, and biofuels) as well as new developments (green hydrogen, carbon capture, use, and storage) whereas energy efficiency implies electrifying the demand, optimizing transmission systems, and distributing and converting equipment.

The just energy transition is met by aligning the following:

1. the technological solution, which occurs when the costs of clean energy production, logistics, and supply to consumers, measured at levelized costs, are lower than high-emission energy sources;
2. the regulatory solution, which occurs when regulations that promote clean technologies and internalize remediation costs are developed, the participation of highly polluting energy sources is limited, and tariffs and incentives promoting energy efficiency are developed;

3. The market solution, which occurs when carbon pricing mechanisms are implemented through taxes or emission certificates to internalize the remediation costs originating from the generated emissions;

4. financing, which occurs when prices and international and Treasury contributions are connected, thus balancing coverage and affordability for all the people as well as cost and investment recovery.

3 Definition of indicators

A set of indicators to assess the just energy transition process and, in particular, measure compliance with the goals associated with its different dimensions, is presented below.

1. Dimensions and topics of just energy transition

Dimensions of just energy transition

- **Institutional aspects.** Incorporate measures relative to climate change in national policies, strategies, and plans; and promote mechanisms to increase effective planning and management capacity in connection with **climate change**. Institutional aspects are a necessary initial condition for JET.

- **Economic/energy aspects.** Value the existing resources in the region; guarantee energy security; increase the share of renewable energy in consumption from energy sources; enhance energy efficiency; expand infrastructure; and limit negative economic externalities. These aspects are related to the promotion of the use of technologies that employ the **resources available in the region**, prioritizing those with the greatest contribution to **economic growth**.

- **Social aspects.** Reduce energy poverty gaps, recognize the legitimate right to develop and guarantee universal access to affordable, reliable, and modern energy services. These aspects are in line with the concept of a JET that seeks to guarantee an **enhancement of the standards of living** towards standards that are compatible with a decent life.

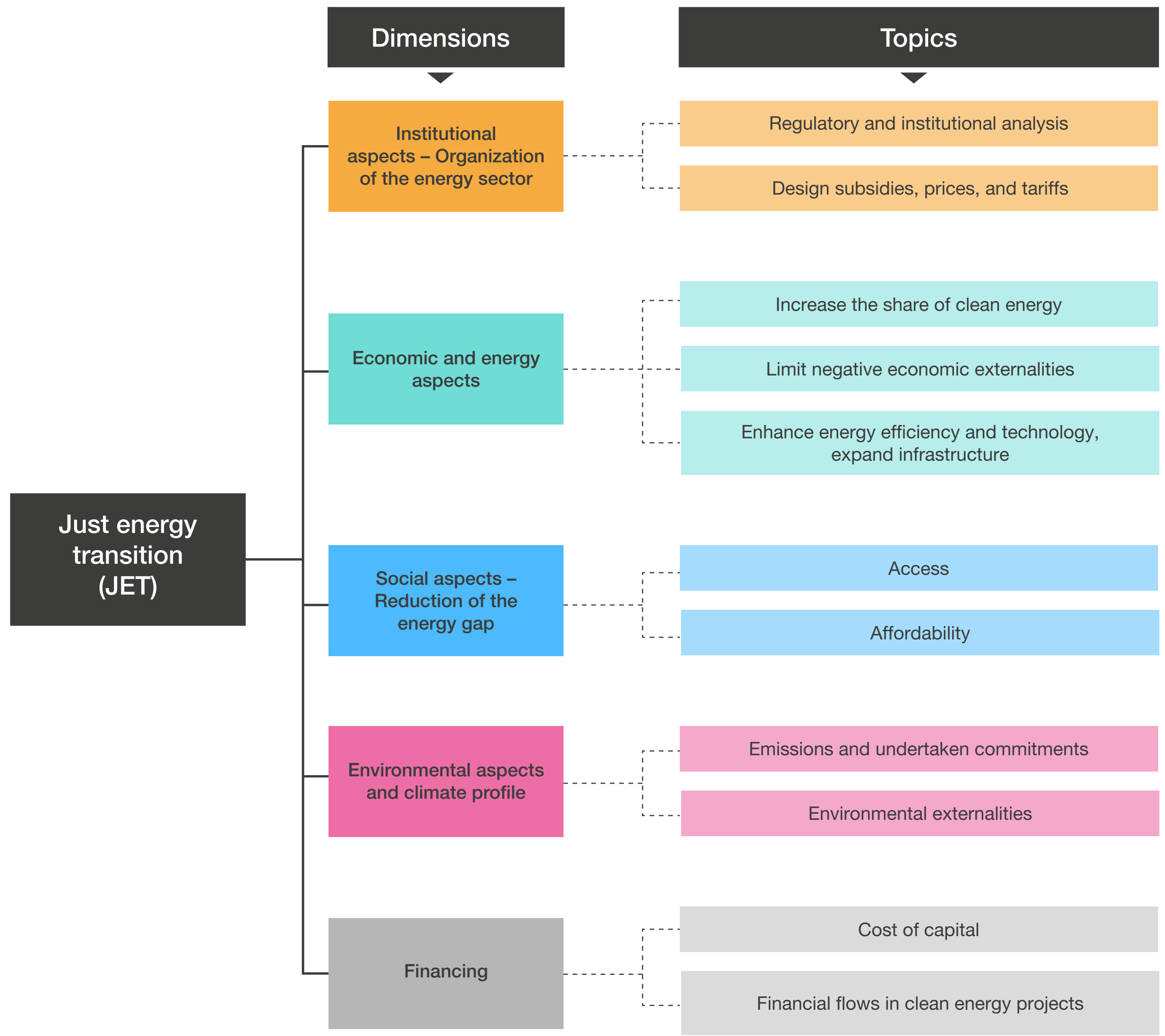
- **Environmental aspects and climate profile.** Reduce the emissions of the equivalent CO_2 (CO_2e) and limit vulnerability to climate change. These aspects enable us to measure the progress of the JET, that is, the conversion process of the energy system and the **gradual reduction** in GHG emissions.

- **Financing.** Have financial resources, reduce the cost of capital, increase international cooperation, and promote investment. Financing is one of the **necessary tools** of the JET.

Dimensions and associated topics

Graphic 11 presents the topics associated with five defined dimensions. These topics are related to goals to be met in the JET environment and allow grouping the indicators into subgroups. Even though most of the indicators are related to the JET, there are others that are important to evaluate aspects that are not related to the energy transition, but to intermediate aspects, such as the evolution of energy subsidies and tariff designs associated with the correct regulation. The topics are developed below; then, a table shows all the indicators and finally, their development.

Graphic 10 ▶ Dimensions and topics of just energy transition (JET)



Source: GME-CAF (July 2023).

Institutional aspects – Organization of the energy sector

The implementation of JET mechanisms depends on institutional aspects and aspects of the organization of the sector, as well as on regulatory framework conditions (suitable or not). Some of the necessary actions include:

- establishing rules related to climate change, assigning responsibilities related to these policies to some well-defined department in charge of developing the JET;
- incorporating measures relative to climate change in the national policies, strategies, and plans;
- promoting mechanisms to increase effective planning and management capacities in connection with climate change;
- managing the population's access to energy (in particular, the lower income population in some countries in the region); tariff policies, taxes on emissions, creating pollution rights, and subsidies; these are aspects of the organization of the sector.

A Regulatory and institutional analysis

The first concept is qualitative; however, climate change and the responsibilities that must be developed over time by the areas in charge of the topic will be dynamic. Dynamism to adopt these new tools or objectives should be recurrently assessed.

The second and the third concepts can be assessed through dedicated indicators to measure, for example, the existence of detailed long-term energy transition strategies and whether such strategies allow for compliance with national environmental commitments.

B Design of subsidies, prices, and tariffs

Access management and tariff policies focus on assessing the alignment of prices with their costs (economic efficiency) for the just energy transition to occur. These tariff policies are essential to implement short-term energy efficiency policies.

In Colombia, Mexico, Peru, and the Dominican Republic, either because of the use of explicit cross subsidies or because of State intervention through the contribution of resources from the budget to the companies providing the service, tariffs do not reflect production costs. This implies that this set of indicators should be met in shorter terms and should be designed in such a way that price signals are allowed.

In the five analyzed countries, there are subsidies or State intervention in the liquid fuel pricing process; for example, Colombia's subsidy scheme is based on strata[14]. This subsidy scheme by property type does not associate it with the level of consumption, which fails to generate an adequate price signal. On the other hand, Peru's Electricity Social Compensation Fund (FOSE, in Spanish) subsidizes consumption levels[15].

14 The National Administrative Statistics Department (DANE, in Spanish), in charge of the classification, indicates that "the socio-economic strata into which houses and land can be classified are 6, known as: 1. low-low, 2. low, 3. medium-low, 4. medium, 5. medium-high, and 6. high. Of these, strata 1, 2, and 3 refer to low strata that lodge lower income users who are beneficiaries of subsidies in residential public services; strata 5 and 6 refer to high strata, which lodge users with higher incomes who must pay cost overruns (contributions) on the value of residential public services. Strata 4 is not a beneficiary of subsidies nor must it pay cost overruns; it pays exactly the value that the company defines as the cost of providing the service.
The classification into any of the six strata is an approximation to the hierarchical socio-economic difference, be it from poverty to wealth or vice versa. As a result of such classification, in one same city you can find such dissimilar houses as those that go from a shack that undoubtedly expresses the destitution of its dwellers to a mansion or small palace, which similarly evidences a huge accumulation of wealth. The same happens in rural areas with houses that go from huts with no walls to ranches, large estates with productive land, and recreation properties with lush amenities".

15 Even though the design of this system is more adequate to generate incentives to efficient consumption, it produces another type of behavior, such as the appearance of more than one meter per property. The utility improves its collectability and the average consumption of its lower-income clients is reduced.

Consequently, subsidy design should allow prices to rise when the average income grows and thus, the energy price signal will incentivize people to consume more efficiently.

Energy efficiency should also relate to subsidies, as they generate inefficient consumption. Therefore, energy efficiency should be developed in coordination with the reduction and eventual redefinition of subsidies in order to reduce the impact of the alignment of prices and costs on the poorer population.

Economic and energy aspects

One first vector of the economic aspects is the level of economic activity, summarized in GDP per capita (at purchasing power parity values, PPP). In this sense, we estimated the need to reach a sufficient GDP per capita to achieve very high human development and meet all the country's energy needs[16].

The just energy transition, in terms of economic and energy aspects, should consider the following:

1. use of local resources;
2. Introduction of energy transition technologies;
3. Economic externalities and job creation.

16 According to the definition of the United Nations Development Programme (UNDP), it is considered that a country has very high human development when its human development index (DI) is equal to or higher than 0.8. in turn, it is considered that a country is able to meet all its energy needs when it shows electric consumption values above 5,000 kWh per capita-year. Finally, in order to establish a margin of minimum GDP levels that countries must reach to be considered developed, the average GDP of the lower quintile of countries with very high HDI and the average GDP of the lower quintile of countries with electric consumptions above 5,000 kWh per capita-year are used. It is concluded that the countries' target GDP per capita to cover their unfulfilled energy needs and to be considered developed is in the range of USD 21,000 to USD 33,000, measured in US dollars of 2017 at PPP.

“Improving energy efficiency and renewable energy are two of the main actions that can accompany an energy transition process, as they are proven technologies or solutions.”

A Use of local resources

The countries in the region have renewable and non-renewable energy resources in different volumes and with different degrees of competitiveness and development potential.

The availability of local resources is related to historical decisions in terms of development of the energy sector in each country and also to future decisions. In particular, they may be an eventual incentive (or an obstacle) to accelerate the energy transition and diversify the sources of energy supply.

Energy security, from the economic perspective, seeks to reduce the exposure of each country’s economy to international price shocks, dependence on other countries’ political agendas[17] and the development of certain local capacities. One of the characteristics of the transition to renewable energy is the reduction of this exposure to the short-term volatility of international prices. In this sense, it is important to characterize the energy independence of a country and its exposure to lack of supply in case of supply tension.

B Introduction of energy transition technologies

Energy efficiency enhancement and an increase in the use of renewable energy are two of the main actions that can accompany an energy transition process, as they are proven technologies or solutions. The increase in the use of renewable energy for electricity production is a requirement before incentivizing the electrification of uses for consumption, particularly in the transportation sector, but also in the other sectors. This increase should be accompanied by an expansion of production, transportation, and distribution infrastructure. It is also necessary to analyze energy efficiency, in connection with final consumption and the chains in the sector (efficiency in generation, transportation, and distribution).

17 For example, the reduction in Argentine reserves as a result of its energy policy decisions deprived Chile of natural gas.

All the countries in the region and most of the countries under analysis have renewable energy resources with different degrees of competitiveness. This tendency appears in a region that, thanks to the organization of its power market, has promoted the introduction of non-conventional renewable energy. The five analyzed countries have promoted tenders for this type of energy.

In addition, the region shows large hydroelectric resources, and high potential to develop biofuels and low-emission hydrogen. Hydroelectric potential has been highly developed in LAC and, at present, it is the region with the greatest use of this type of energy in the world. Biofuels are largely developed in LAC, according to the type of biomass. On the other hand, land extension and availability allow the region to have very promising areas for green hydrogen.

Finally, the efficient use of energy, measured in terms of contribution to the economy, has to improve over time to ensure an efficient energy transition.

C Economic externalities and job creation

For developing countries, the transition must:

- Limit the negative economic externalities that may be related to:
  - job displacement;
  - lack of revenues (either fiscal or private) from activities depending on the consumption of fossil fuels;
  - loss of use of stranded assets;
  - incentivize positive externalities, such as the creation of jobs related to the development of new energy transition solutions.

In several countries in LAC, technologies for biomass use for the transportation sector (ethanol, biodiesel) are highly developed. These biofuels, together with industries related to food and forestry developments for pulp, which produce a high auto-generation level[18], generate a large number of jobs that must be maintained. The energy (and non-energy) transition must envisage that these sectors maintain their production levels and, if possible, grow as long as they do not generate negative environmental externalities (particularly, in land use).

The process of introducing renewable energy in power generation is a fact in many economies in the region, but the development of local industries for the construction of solar panels or wind motors is limited[19]. However, new businesses associated with the exploitation of distributed energy have developed, as well as companies working on the operation and maintenance of these renewable plants. Job creation in these sectors would allow replacing the existing positions in sectors with environmental externalities.

18 Coffee in Brazil and Colombia; peanuts in Argentina; sugar in Guatemala, El Salvador, Brazil, and Argentina; pulp in Uruguay, Argentina, Brazil, Chile, etc.

19 It is important to mention that the development of local industry is not the objective, but that the countries in the region take advantage of the opportunity to develop new industries that will allow them to industrialize.

Social aspects – Reduction of the energy gap

A JET cannot take place without, as a first step, **guaranteeing universal access to affordable, reliable, and modern energy services**, for all the population, reducing energy poverty gaps, and recognizing the legitimate right to develop.

A Access

Even though Latin America and the Caribbean show relatively high levels of access to energy (especially electricity) (in general, higher than 90 % or 95 % of the population), the average consumption is low, and in many countries in the region, households continue consuming “non-modern sources of energy”, for example, firewood, as the main fuel for cooking.

On the other hand, there is significant disparity in terms of energy consumption between households and between countries. According to the Economic Commission for Latin America and the Caribbean (CEPAL)[20], in emerging market and developing economies, the lower income quintile consumes nine times less energy than that with higher income. The quality of the service in the poorer households is also lower. Guaranteeing access to equitable and quality energy services is a necessary condition to reduce inequality and poverty and facilitate growth.

B Affordability

Affordability is a necessary condition for socio-economic development in the future. The implementation of measures to fight against energy poverty will help reduce gaps and achieve a JET. Tariffs should be affordable

20 https://www.cepal.org/sites/default/files/news/files/cepal_alc_transicion_energetica.pdf

(possibility of having social tariffs for certain categories of the population) and, in turn, allow recovering costs and promoting rational consumption of the resources.

Environmental aspects

A JET must be accompanied by:

- a reduction in CO_2e emissions, and
- a limitation of vulnerability to climate change.

A Emissions and undertaken commitments

Energy transition processes on a national and international basis are currently conditioned to environmental compliance, particularly in terms of CO_2 emissions. The signing countries to the Paris Agreement have committed to “reach a balance between anthropogenic emissions by source and anthropogenic absorptions by sinks in the second half of the century”. As part of the pathway to achieve carbon neutrality, each country has defined its nationally determined contributions (NDC) for 2030.

B Environmental externalities

The impact of the current and future change is not uniform in all countries. Lower income countries tend to be more exposed to the impact of climate change although they are responsible for only a very limited portion of total emissions. Assessing both the occurrence of extreme natural events and disasters as well as the countries’ vulnerability facilitates planning solutions to face such consequences.

In turn, it also helps to incentivize more actions to fight against climate change. These indicators allow focusing on remediation and adaptation.

Financing

Financing can be analyzed from two lines of action: availability and cost. Having financial resources and reducing the cost of capital are the key elements to make the just energy transition viable.

In order to have resources, the just energy transition should be accompanied by an increase in international cooperation and local schemes that promote investment in aspects related to energy transition.

In its Article 9, the Paris Agreement establishes the need for developed countries to support developing countries financially. In particular, "developed country Parties should continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments, and channels, noting the significant role of public funds (…) and taking into account the needs and priorities of developing country Parties. Such mobilization of climate finance should represent a progression beyond previous efforts".

Apart from these potential financial contributions, it is essential that each country have a favorable general framework when providing financing to the private sector and a competitive cost of capital[21] that facilitates investment from both local and international private capital.

In addition, fiscal/tax dependence on production chains associated with hydrocarbons must be assessed to evaluate the expected impact of a just energy transition process, and remediate the economic impact of not exploiting local resources by developing other fiscal or tax sources related to transition projects. For example, part of the budgets of countries like Colombia and Mexico are financed with revenues from hydrocarbons.

21 In infrastructure businesses, high cost of capital rates incentivizes strategies with high maintenance cost and low investment cost, that is, they disincentivize the incorporation of new projects. Low cost of capital is a necessary condition to accelerate the just energy condition.

2. Indicators by dimensions and topics

List of indicators

Table 4 presents the list of indicators by dimension and topic. Each of these indicators is described in Chapter 4.

Table 4 Dimensions, topics, and potential indicators (IESAF scheme)

Dimensions	Topics	Index	Potential indicators
I - Institutional aspects – Organization of the sector	1. Regulatory and institutional analysis	I-1.1	Rules and governance in the energy sector
		I-1.2	Existence of energy transition strategies
		I-1.2.bis	Effectiveness of energy transition strategies
	2. Design of subsidies, prices and tariffs	I-2.1	Subsidies to fuels (% of GDP)
		I-2.2	Total expenditure on subsidies (BUSD) and expenditure on subsidies for electricity (BUSD)
E - Economic and energy aspects	1. Use of local resources	E-1.1	Proven reserves of local resources
		E-1.2	Dependence on net energy imports (%)
	2. Introduction of energy transition technologies	E-2.1	Share of renewable energy in total final energy consumption and power generation (%)
		E-2.1bis	Installed renewable generation capacity (GW)
		E-2.2	Energy intensity measured on the basis of primary energy and GDP (TJ/MUSD PPP)
		E-2.3	Efficiency of energy conversion and distribution (%)
		E-2.4	Energy intensity by economic sector (TJ/MUSD PPP)
		E-2.5	Energy intensity of the residential sector (TJ/household)
		E-2.6	Penetration of electricity in the transportation sector (%)
		E-2.7	Penetration of natural gas and hydrogen in the transportation sector (%)
	3. Economic externalities and job creation	E-3.1	Installed capacity (GW) and value of stranded assets (MUSD)
		E-3.2	Number of formal employees associated with existing value chains
		E-3.3	Number of jobs associated with energy transition projects (thousands of job positions)

Continues.

Continuation.

Dimensions	Topics	Index	Potential indicators
S - Social aspects – Reduction of the energy gap	1. Access	S-1.1	Share of the population with access to electricity
		S-1.2	Share of the population whose primary energy source consists in clean technologies and fuels
		S-1.3	Energy use per capita
		S-1.4	Electric service quality
	2. Affordability	S-2.1	Final tariff by sector and fuel
		S-2.2	Share of household income devoted to fuel and electricity, for the total and for the 20% poorer households
A - Environmental aspects and climate profile	1. Emissions and undertaken commitments	A-1.1	Total GHG emissions per year and sector (MtCO2e)
		A.1.2	Total GHG emissions by GDP unit and per capita (MtCO2e/MUSD PPP and tCO2e per capita)
	2. Environmental externalities	A-2.1	Number of people directly affected attributed to disasters per 100,000 inhabitants
		A-2.2	Vulnerability and preparation for climate change
F - Financing	1. Cost of capital	F-1.1	Cost of indebtedness of the private sector
	2. Financial flows in clean energy projects	F-2.1	International financial flows to developing countries to support research and development of clean energy and renewable generation production, including hybrid systems
		F-2.2	Fiscal/tax dependence of production chains associated with hydrocarbons

Source: GME-CAF (July 2023).

As a general rule, existing indicators are presented for most of the analyzed topics. In the case of those aspects for which there is no indicator built by third parties, we seek to present indicators with low construction costs or with easily obtained sources.

Description of the indicators

Organization of the energy sector

INSTITUTIONAL ASPECTS

GOALS TO BE MET

Incorporate measures related to climate change in national policies, strategies, and plans; promote mechanisms to increase effective planning and management capacity in connection with climate change.

A Regulatory and institutional analysis

Rules and governance of the energy sector

Definition. Existence of rules issued by the highest authorities, which define the goals and responsibilities of public policy related to the just energy transition.

Usefulness in the context of the project. Indicator I-1.1 allows us to analyze the alignment of the regulations to achieve the objectives set in the Paris Agreement.

Data availability and/or preparation. It was carried out in accordance with indicators contained in the Energy Sector Management Assistance Program (ESMAP), Regulatory Indicators for Sustainable Energy (RISE)[22], which allow comparing national policies and regulatory frameworks for sustainable energy. These indicators have four components.

22 https://rise.esmap.org/indicators

- Access to electricity: it covers aspects such as the existence of electrification plans and their availability, goals, scope, affordability, etc.
- Clean cooking: it includes the existence of planning, its scope, institutional capacity, awareness programs, labeling programs, financial incentives, etc.
- Renewable energy: it covers the legal framework for renewable energy, expansion plans for this energy, incentives and regulatory support, integration of renewable energy to the grid, emission monitoring, etc.
- Energy efficiency: it includes national energy efficiency plans, related institutions, incentives to the different sectors, financing mechanisms, minimum energy performance standards (MEPS), labeling systems, etc.

Existence of energy transition strategies

Definition. Existence of long-term energy transition strategies, NDC, detailed plans, etc.

Usefulness in the context of the project. Indicator I-1.2 allows us to evaluate the existence and incorporation of measures related to climate change in national policies, strategies, and plans.

Data availability and/or preparation. Support in official documents issued by the pertinent institutions in each of the countries involved in the study.

Effectiveness of energy transition strategies

Definition. Effectiveness of energy transition strategies in the long term, NDC, detailed plans, etc.

Usefulness in the context of the project. Indicator I-1.2bis allows us to evaluate the incorporation of measures related to climate change in national policies, strategies, and plans and their potential impact on the pathway towards net zero emissions.

- **Data availability and/or preparation.** Support in the Climate Action Tracker (CAT)[23] indicator, which evaluates and qualifies climate actions proposed by each country against compliance with the NDC and the carbon neutrality target in 2050 as:
  - 1 – Critically insufficient
  - 2 – Highly insufficient
  - 3 – Insufficient
  - 4 – Almost sufficient
  - 5 – Compatible with 1.5 °C target

B Subsidies, prices, and tariffs

Subsidies to fuel (% of GDP)

- **Definition.** Total subsidies received to country's GDP.
- **Usefulness in the context of the project.** Indicator I-2.1 allows us to evaluate the impact of subsidies on the national economy. Even though subsidies may facilitate access to energy in the poorer households, their drawback is that they incentivize consumption and disincentivize the implementation of energy efficiency measures.
- **Data availability and/or preparation.** The IMF publishes a subsidy base by fuel type that shows the participation of subsidies in the GDP[24].

23 https://climateactiontracker.org/countries/

24 https://www.imf.org/en/Publications/WP/Issues/2023/08/22/IMF-Fossil-Fuel-Subsidies-Data-2023-Update-537281

Total expenditure on sector subsidies (BUSD) and expenditure on electricity subsidy (BUSD)

- **Definition.** Total subsidies received by the energy sector (including oil, coal, natural gas, and electricity) and subsidies for the power sector only.
- **Usefulness in the context of the project.** Indicator I-2.2 allows us to evaluate the investment in fossil fuels made by society that can be redirected to other uses.
- **Data availability and/or preparation.** The IMF publishes a subsidy base by fuel type that shows the countries' total expenditure on subsidies[25].

25 https://www.imf.org/en/Publications/WP/Issues/2023/08/22/IMF-Fossil-Fuel-Subsidies-Data-2023-Update-537281

ECONOMIC AND ENERGY ASPECTS

GOALS TO BE MET

Increase the share of renewable energy in consumption from energy sources and guarantee energy security; expand infrastructure, enhance energy efficiency, and improve technology; and limit negative economic externalities.

A Use of local resources

Proven reserves of local resources

- **Definition.** Proven reserves by fuel (in energy units, volume or weight, as applicable). It is prepared for oil, natural gas, coal and uranium (4 sub-indicators).
- **Usefulness in the context of the project.** Indicator E-1.1 is a marker of each country's energy independence and is related to past decisions in terms of energy sector development.
- **Data availability and/or preparation.** Indicator published by the Permanent Secretariat of the Latin American Energy Organization (OLADE) by source in Latin America and the Caribbean (sieLAC[26]).

26 https://sielac.olade.org/default.aspx

Dependence on net energy imports (%)

- **Definition.** Net energy imports (imports less exports) divided by total energy supply. "Energy" refers to primary energy plus secondary energy.
- **Usefulness in the context of the project.** Indicator E-1.2 allows us to characterize a country's energy independence, its exposure to lack of supply in case of supply tension, and the eventual incentive to accelerate its energy transition and diversify energy supply sources.
- **Data availability and/or preparation.** OLADE publishes the external energy dependence index in its energy information system (sieLAC[27]).

B Introduction of energy transition technologies

Share of renewable energy in total final energy consumption and electricity generation (%)

- **Definition.** This indicator is divided into two sub-indicators:
  - the ratio of renewable energy to total final energy consumption
  - the ratio of renewable power generation to total power generation

  The following energy sources are considered to be renewable: hydroelectric, solid biofuels, wind, solar, liquid biofuels, biogas, geothermal, marine, and waste.

27 https://sielac.olade.org/default.aspx

Usefulness in the context of the project. Indicator E-2.1 allows us to measure the future increase in the amount of renewable generation and energy and participate in the diversification targets, which are necessary conditions for a reduction in CO_2e emissions and an energy transition.

Data availability and/or preparation. The indicator is part of the United Nations Sustainable Development Goals (SDGs) database and was defined by the International Atomic Energy Agency (IAEA) in its document *Energy indicators for sustainable development: guidelines and methodologies* (ECO13). The share of renewable energy in the total energy consumption can be found in the SDG database (indicator 7.2.128[28]). it is possible to calculate the share of renewable energy in power generation from the system operator data or sieLAC information (OLADE), among others.

Installed renewable generation capacity (GW)

Definition. Installed renewable generation capacity

Usefulness in the context of the project. Indicator E-2.1bis supplements E-2.1 with data in terms of infrastructure and development of the sector to be compared with other countries.

Data availability and/or preparation. The indicator is part of the United Nations SDG database (SDG, 7.b.1)[29]. This information is published by national institutions responsible for managing the electricity dispatch which, in certain cases, are state-run companies in the power sector, or by sieLAC (OLADE).

28 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=3883

29 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=4289

Energy intensity measured by primary energy and GDP (TJ/1,000 USD PPP 2017)

Definition. Ratio of primary energy supplied to GDP, expressed in constant USD at purchasing power parity.

Usefulness in the context of the project. Indicator E-2.2 is an indicator of the global productivity of the country; its evolution contemplates the modification of the economic structures of a country and the eventual energy efficiency enhancements.

Data availability and/or preparation. The indicator is part of the United Nations SDG database (SDG, 7.3.1[30]).

Energy conversion and distribution efficiency (%)

Definition. This indicator is divided into two sub-indicators:

- difference between the primary energy destined to a transformation process and the resulting secondary energy, divided by the primary energy;
- difference between the generated energy and the consumed energy, divided by the generated energy.

Usefulness in the context of the project. The two sub-indicators included in indicator E-2.3 allow us to measure the energy efficiency of energy processes. The first sub-indicator is a measure of efficiency in the process of producing energy whereas the second sub-indicator estimates the efficiency level in the power transmission and distribution process. Both the efficiency enhancement of processes and the loss reduction in the power sector are very necessary in an energy transition process.

30 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=3884

- **Data availability and/or preparation.** Indicator defined by the IAEA in its document *Energy indicators for sustainable development: guidelines and methodologies* (ECO3). Energy consumption for power generation comes from the energy balance[31] and the electricity generated by fuel from institutions in the countries' power market. The second indicator is only prepared with information from the energy balances published by OLADE.

Energy intensity by economic sector (TJ/1,000 USD)

- **Definition.** Ratio of final consumption by sector to GDP by sector (industrial, commercial, agricultural, fishing, and mining). In the transportation sector, the consumption of the sector to total GDP of the economy is considered.
- **Usefulness in the context of the project.** Indicator E-2.4 is an indicator of each sector's productivity. Its evolution contemplates eventual energy efficiency enhancements or structure modifications by subsector of each sector.
- **Data availability and/or preparation.** Indicators defined by the IAEA in its document *Energy indicators for sustainable development: guidelines and methodologies* (ECO6, ECO7, ECO8, ECO10). It is a calculation made from the national energy balance published by the OLADE or national institutions, the GDP data published in the World Bank's indicator base[32] (in constant USD at purchasing power parity) and the countries' national accounts.

Energy intensity of the residential sector (TJ/1,000 inhabitants)

- **Definition.** Ratio of final consumption of the residential sector per 1,000 inhabitants.

31 https://sielac.olade.org/default.aspx

32 https://data.worldbank.org/indicator/

- **Usefulness in the context of the project.** Indicator E-2.5 is an indicator of the residential energy efficiency enhancement or the increase in energy uses by household, which may accompany economic growth.
- **Data availability and/or preparation.** Indicator defined by the IAEA in its document *Energy indicators for sustainable development: guidelines and methodologies* (ECO9). It is a calculation made from the national energy balance published by the OLADE or national institutions and information on population taken from the World Bank.

Penetration of electricity in the transport sector (%)

- **Definition.** Penetration of electricity in transportation sector consumption (%).
- **Usefulness in the context of the project.** Indicator E-2.6 shows the replacement of hydrocarbon consumption, one of the main sources of emissions from electricity. It will help to analyze the convenience of promoting public policies to accelerate this replacement.
- **Data availability and/or preparation.** The national energy balance published by the sieLAC (OLADE) includes the electric power consumption of the transportation sector and reflects the aggregated evolution of the sector (including road passenger and freight transportation, railway, etc.).
- In the future, a more detailed indicator could be the number of private electric road transportation vehicles (motorcycles and cars) to focus on this segment of the transportation sector. The data of the operative fleets of the countries by vehicle type is organized in different ways; therefore, at present, this indicator would be difficult to build.
- In the future, a more detailed indicator could be the number of vehicles associated with road freight transportation that consume natural gas and hydrogen. The data on the operative fleets of the countries is organized in different ways; therefore, at present, this indicator would be difficult to build.

“The analyzed indicators contemplate institutional, economic/energy, social, environmental, and financial aspects”.

C Economic externalities and job creation

Installed capacity (GW) and value of stranded assets (MUSD)

- **Definition.** Installed capacity of the assets that are not used in an energy transition scenario (stranded assets, in MW) along with their written-off economic value (in millions of constant USD at purchasing power parity).
- **Usefulness in the context of the project.** Indicator E-3.1 allows us to evaluate the capital loss related to an energy transition scenario in case of not using or strongly limiting the use of assets that have not yet reached the end of their useful lives.
- **Data availability and/or preparation.** This indicator is difficult to prepare if one seeks to know the real value of the stranded assets. Moreover, these assets reflect the investor’s efficiencies or inefficiencies. Therefore, to simplify its preparation, we propose the use of an indicator of stranded assets in terms of efficient values of the technologies as new, that is, the value that should be repaid if the plants operated until the end of their useful lives. For power generation plants, a value of the technology in MW would be used; for oil or gas reserves, an estimation of the non-exploited value, such as the price at the time of stranding by the volume of oil or gas that could be extracted if the normal depreciation term of the residual lives were completed. This indicator must be evaluated in the future (current zero value).

Number of formal employees associated with existing value chains

- **Definition.** Number of formal employees associated with existing value chains, for example, the coal sector (including jobs related to coal mines and power plants).

- **Usefulness in the context of the project.** Indicator E-3.2 allows us to evaluate eventual job losses to estimate the social impact of the energy transition measures and ensure a just transition, and takes into consideration the need for training and reconversion of people and economic zones.
- **Data availability and/or preparation.** The indicator depends on the availability of data on formal employment on a national basis by sector and subsector. This data is available in most of the countries in the region. However, it is necessary to push forward the opening of this data for the sectors associated with the energy sector in renewable energy projects[33] and non-renewable energy projects. This indicator will be available pursuant to the results informed in the CAF's *Report on Economy and Development* (RED 2024).

Number of jobs associated with energy transition projects (thousands of job positions)

- **Definition.** Number of formal employees associated with energy transition projects.
- **Usefulness in the context of the project.** Indicator E-3.3 allows us to evaluate the number of new jobs created and associated with transition projects to estimate the social impact of the energy transition measures and ensure a just transition.
- **Data availability and/or preparation.** The indicator depends on the availability of data on formal employment on a national basis by sector and subsector. This data is available in most of the countries in the region. However, it is necessary to push forward the opening of this data for the energy efficiency and renewable energy aspects. The ILO has general statistics but they are not open in the indicated segments. The IRENA publishes jobs for the renewable energy sector[34]. Even though this is partial information (it does not take into account the other actions related to the JET) it may be a first approximation to consider. This indicator will be available pursuant to the results reported in the RED 2024.

33 Depending on the country considered, there is information on "green jobs", which contribute to preserving and restoring the environment, either in the traditional sectors or in new emerging sectors, such as renewable energy and energy efficiency, under the website of the International Labour Association (ILO)

Definition of indicators

34 https://www.irena.org/Data/View-data-by-topic/Benefits/Renewable-Energy-Employment-by-Country

Reduction of the energy gap

SOCIAL ASPECTS

GOAL TO BE MET

Guarantee universal access to affordable, reliable, and modern energy services

A Access

Share of the population with access to electricity (%)

- **Definition.** Ratio of the amount of the population with access to electricity to the total amount of population. It is considered that a person has access to electricity if their main source of electricity is their local power supplier, solar systems, mini grids, or stand-alone power systems.
- **Usefulness in the context of the project.** Indicator S-1.1 is a marker of access to reliable, modern, and potentially clean energy services (depending on the power generation mix). The electrification of uses, accompanied by the development of renewable generation, is one of the pillars of energy transition. This indicator can be broken down into rural and urban population to identify the gaps in power distribution more closely.
- **Data availability and/or preparation.** Indicator that is part of the United Nations SDG database (SDG, 7.1.1[35]).

35 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=3881

Share of the population whose primary energy source consists of clean technologies and fuels (%)

- **Definition.** Ratio of the share of the population using clean technologies and fuels for cooking, space heating, and lighting to the total population. A fuel is considered to be clean if it meets certain emission rates and quality criteria regarding indoor air, as described in the World Health Organization (WHO)'s regulation on the quality of indoor air[36]. In particular, it is recommended that unprocessed coal and kerosene should not be used, and the importance of combining adequate technologies with clean fuels is pointed out.
- **Usefulness in the context of the project.** Indicator S-1.2 is a marker of access to reliable, modern, and clean services, a necessary requirement for energy transition.
- **Data availability and/or preparation.** The indicator is part of the United Nations SDG database (SDG, 7.1.2[37]).

Energy use per capita (TJ/1,000 inhabitants)

- **Definition.** Ratio of final national annual consumption to the total population in the middle of the year.
- **Usefulness in the context of the project.** Indicator S-1.4 is an indicator of the average per capita energy use level that can be compared to that of developed countries. Even though this indicator comprises specific socio-economic factors in each country (energy consumption of production sectors,

36 https://apps.who.int/iris/bitstream/handle/10665/144310/WHO_FWC_IHE_14.01_spa.pdf?sequence=1&isAllowed=y

37 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=3882

classification of the population into rural/urban, etc.), it may be useful to have orders of magnitude of the use of energy (a low value is often a marker of the lack of access to energy services of part of the population).

- **Data availability and/or preparation.** Indicator defined by the IAEA in its document *Energy indicators for sustainable development: guidelines and methodologies* (ECO1). The IARA base of indicators per country is not available. However, this indicator can be calculated from the national energy balance (published by OLADE or the national office of statistics) and the total population towards the middle of the year (published by the World Bank or the national office of statistics).

Quality of electricity service

- **Definition.** The quality of the electricity service is estimated from two sub-indicators: the frequency of power service interruptions (System Average Interruption Frequency Index, SAIFI) and the average duration of the interruptions (System Average Interruption Duration Index, SAIDI). The SAIFI and the SAIDI are calculated as indicated below:

$$\text{SAIFI} = \frac{\sum \text{users interrupted in "n" interruptions}}{\sum \text{supplied users}} \quad \text{in [interruptions/user-year]}$$

$$\text{SAIDI} = \frac{\sum \text{hours by interrupted user in "n" interruptions}}{\sum \text{supplied users}} \quad \text{in [hours/user-year]}$$

- **Usefulness in the context of the project.** Indicator S-1.5 is a marker of the quality of the electricity service that can be compared to the objective country levels or to the levels obtained in developed countries. A good quality of service is a necessary condition for economic development and should accompany any energy transition process.

- **Data availability and/or preparation.** Indicators that are often calculated by power utilities and are grouped together on a national basis by state-run institutions, such as the ANEEL (National Electricity Agency) in Brazil, the Superintendency of Household Public Services in Colombia, the Regulatory Energy Commission in Mexico[38], the Osinergmin in Peru, the Superintendency of Electricity in the Dominican Republic[39]. In general, the information available by country only helps to characterize the households connected to the public service of power distribution. Data on households in isolated areas is missing. The CIER (Regional Energy Integration Commission) has compiled the data for the region. Publications by other institutions also contain information by country (for example, CAF[40] or IADB[41]).

B Affordability

Final tariff by sector and fuels

- **Definition.** Final tariff by sector (residential, industrial, commercial) and fuel (electricity, gas), including eventual taxes and subsidies. Tariffs should reflect both the variable price and the eventual fixed price that may refer to a monthly payment.

38 https://www.gob.mx/cms/uploads/attachment/file/683779/RCSEN_2019_VF.pdf

39 Brazil: https://antigo.aneel.gov.br/indicadores-coletivos-de-continuidade
Colombia: https://www.superservicios.gov.co/sites/default/files/inline-files/Informe-de-Calidad-del-Servicio-de-Energia-2021.pdf
Mexico: https://www.gob.mx/cms/uploads/attachment/file/683779/RCSEN_2019_VF.pdf
Peru: https://observatorio.osinergmin.gob.pe/saidi-saifi-departamentos
Dominican Republic: https://sie.gob.do/indicadores-calidad-distribuidoras/

40 https://scioteca.caf.com/handle/123456789/1980

41 https://publications.iadb.org/es/impacto-de-la-regulacion-en-la-calidad-del-servicio-de-distribucion-de-la-energia-electrica-en. For Mexico, the following document was used: https://www.gob.mx/cms/uploads/attachment/file/683779/RCSEN_2019_VF.pdf

- **Usefulness in the context of the project.** Indicator S-2.1 offers information on the affordability of energy services to the population, a necessary condition for socio-economic development in the future. On the other hand, the price level has a strong impact on final energy consumption, and incentivizes (or not) the development of energy efficiency solutions, helping to save energy.

- **Data availability and/or preparation.** Indicator defined by the IAEA in its document *Energy indicators for sustainable development: guidelines and methodologies* (ECO14). The IAEA base of indicators per country is not available. However, this indicator can be estimated from the final electricity or gas tariffs published by national agencies or traders, considering the variable portion and the fixed payment. Tariffs must be expressed in constant USD at purchasing power parity to be comparable between years and countries. In the case of power utilities, the information may be obtained from the CIER. Argus has the domestic and international tariffs of all fuels. The OLADE also publishes reports with data by country in the region[42], as well as other sources[43].

Share of household income devoted to fuel and electricity, for the total and for the 20 % poorer households (%)

- **Definition.** Total energy expenditures (including fuels and electricity) divided by household incomes. If the information is available, this indicator can be calculated for the total population and for the 20 % poorer households.

- **Usefulness in the context of the project.** Indicator S-2.2 helps to characterize the affordability of the energy services, a necessary condition for future socio-economic development and a just energy transition. On an individual basis, this indicator allows us to evaluate energy poverty situations in the poorer households (where energy expenditure is higher than 10 % of the household income). The use of the 20 % poorer households allows us to visualize the fight against poverty.

- **Data availability and/or preparation.** Indicator defined by the IAEA in its document *Energy indicators for sustainable development: guidelines and methodologies* (SOC2). The IAEA base of indicators per country is not available. However, this indicator can be estimated from household income and expenditure surveys (HIES), if available. Statistics related to household income and expenditure surveys is different by country and many of the countries in the region do not have a permanent update, which will make the data difficult to compare between countries. Anyway, this indicator will be available pursuant to the results reported in the RED 24.

42 https://biblioteca.olade.org/opac-tmpl/Documentos/old0463.pdf

43 https://www.globalpetrolprices.com/electricity_prices/

Definition of indicators

ENVIRONMENTAL ASPECTS

GOALS TO BE MET

Reduction in CO_2e emissions and vulnerability to climate change

A Emissions

Total GHG emissions per year and sector ($MtCO_2e$)

- **Definition.** Total GHG emissions by year and by sector (energy, industrial processes, agriculture, change in land use and forestry, waste).
- **Usefulness in the context of the project.** Indicator A-1.1 allows us to follow the annual evolution of GHG emissions and see if they aim to comply with the national commitments (NDC and Paris Agreement).
- **Data availability and/or preparation.** The indicator is part of the United Nations SDG database (SDG). However, in this case, the published data does not include the emissions related to “change in land use and forestry”. Possible evaluation from the national emissions inventory generally published by national agencies, the UNFCCC, or Climate Watch.

Total GHG emissions per GDP unit and per capita ($MtCO_2e$/MUSD PPP and tCO_2e/capita)

- **Definition.** Total GHG emissions per GDP unit and per capita. It is indicator I-4.1.1 divided by the GDP or the total population.
- **Usefulness in the context of the project.** Indicator A-1.2 allows us to follow the annual evolution of unitary GHG emissions and compare them to other countries (the comparison of the total amount is more difficult given the differences in relative size of the countries).
- **Data availability and/or preparation.** Possible evaluation starting from indicator A-1.1 divided by total GDP or total population, according to a publication by the World Bank or national agencies.

B Environmental externalities

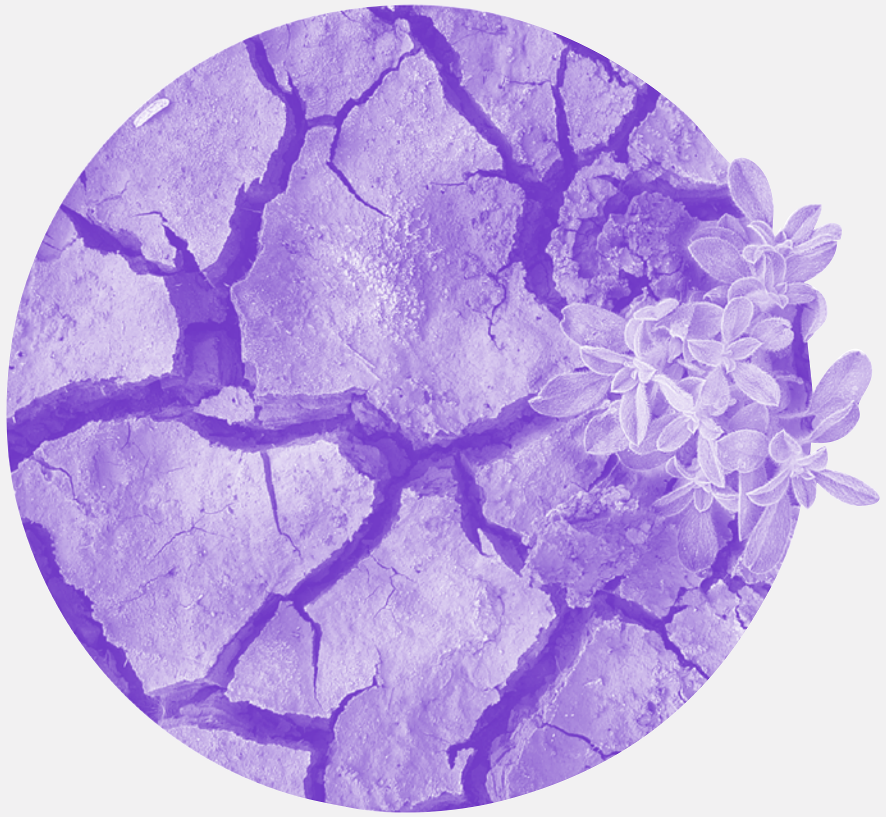
Number of people directly affected, attributed to disasters per 100,000 inhabitants

- **Definition.** Number of people directly affected attributed to disasters per 1,000 inhabitants (storms, floods, landslides, extreme temperatures, droughts, and fires).
- **Usefulness in the context of the project.** Indicator A-2.1 is a marker of the national impact of climate change, which may add incentives in this pathway towards energy transition.
- **Data availability and/or preparation.** This indicator is part of the United Nations SDG database (SDG, 13.1[44]). The database also contains indicators of economic impact such as total damage (in millions of USD) and reconstruction costs, which could also be used.

44 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=1837

Vulnerability and preparation for climate change

- **Definition.** The ND-GAIN index reflects a country's vulnerability to climate change in combination with its preparation to enhance resilience. Vulnerability is measured through a country's exposure, sensitivity, and capacity to adapt to the negative effects of climate change. A country's preparation to enhance its resilience to climate change is measured through its capacity to take advantage of investment and turn it into climate adaptation actions, which depends on economic, social, and governance factors.
- **Usefulness in the context of the project.** Indicator A-2.2 e is very useful to evaluate a country's preparation to enhance its resilience to climate change.
- **Data availability and/or preparation.** It is an indicator defined and calculated by the University of Notre-Dame at Lille[45].



45 https://gain.nd.edu/our-work/country-index/

"A country's readiness to improve its climate resilience is measured by its ability to leverage investments and turn them into climate adaptation actions, which depends on economic, social, and governance factors."

FINANCIAL ASPECTS

GOALS TO BE MET

Increase international cooperation and promote investment

A Cost of capital

Cost of indebtedness of the private sector

- **Definition.** Cost of indebtedness of top leading companies in local markets or through the banking system.
- **Usefulness in the context of the project.** Indicator F-1.1 allows us to evaluate the indebtedness feasibility of the private sector in a context of great need for investment to accompany the energy transition process.
- **Data availability and/or preparation.** Central banks and stock markets[46] publish the annual preferential rates.

46 Sources proposed by country:
Brazil: https://www.bcb.gov.br/estatisticas/txjuros; Colombia: https://www.banrep.gov.co/es/estadisticas/prime;
Peru: https://www.bcrp.gob.pe/docs/Publicaciones/Nota-Semanal/2023/resumen-informativo-2023-08-31.pdf;
Mexico: https://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?accion=consultarCuadro&idCuadro=CI34&locale=es
Dominican Republic: https://www.bancentral.gov.do/a/d/2536-sector-monetario-y-financiero

B Financial flows in clean energy projects

International financial flows towards developing countries to support research and development of clean energy and renewable energy production

- **Definition.** The financial flows considered are official loans, subsidies, and capital investment destined to research and develop clean energy and renewable energy production, including the hybrid systems from the Creditor Statement Report (CSR) of the Organization for Economic Cooperation and Development (OECD)/Development Assistance Committee (DAC).
- **Usefulness in the context of the project.** Indicator F-2.1 allows us to follow up on compliance with the goal of increasing international cooperation.
- **Data availability and/or preparation.** This indicator is part of the United Nations SDG database (SDG, 7a.1[47]). The sources used by the SDG are the OECD and the IRENA.

Fiscal/tax dependence of productive chains related to hydrocarbons (%)

- **Definition.** Ratio of tax resources generated by the hydrocarbon sector to total tax resources.
- **Usefulness in the context of the project.** Indicator F-2.2 allows us to evaluate the eventual obstacles to the energy transition in case of having high fiscal/tax dependence on production chains associated with hydrocarbons.

47 https://agenda2030lac.org/estadisticas/technical-sheet.html?lang=es&indicator_id=4206

- **Data availability and/or preparation.** Information from the IDEAL report published by the CAF (Graphic 2.12, p. 65)[48] can be used and updated pursuant to the results reported in the RED 2024.

3. Update on the indicators

The indicators prepared herein refer to different databases that present information related to the last finished year or a previous year, as is done in this report.

The update on the indicators must be performed on an annual and cumulative basis from the database presented in this report.

The construction of the database towards previous years, based on 2015, is also recommended.

48 https://scioteca.caf.com/handle/123456789/1980

4 Indicators by country for the base line

Table 5 contains the indicators for the five countries in the region selected by CAF (Brazil – BRA, Colombia – COL, Mexico – MEX, Peru – PER, and the Dominican Republic RDO). The base year for the indicators was 2019, in order to avoid the effects of the COVID event on the indicators, except for some indicators mentioned in the note to Table 5.

Table 5 Indicators by country for the base line (2019)

Number	Potential indicators	Unit	BRA	COL	MEX	PER	RDO
I-1.1	Rules and governance	%	82%	76%	85%	65%	63%
I-1.2	Existence of energy transition strategies		NDC/ No clear policy	NDC/ Energy transition policy	NDC/ ENTEASE[49]	NDC/ Roadmap of energy transition	NDC/ National energy plan
I-1.2.bis	Effectiveness of the transition strategies	1 to 5[50]	3	3	2	3	N/A
I-2.1	Fuel subsidies (% of GDP)	%	3%	8%	8%	5%	12%
I-2.2	Total expenditure of the sector on subsidies	BUSD	69	34	98	12	13
	Total expenditure on subsidies (electricity)	BUSD	0	0.1	3.7	0	1
E-1.1	Proven reserves, oil	Mbbl	12,714	2,041	6,066	345	-
	Proven reserves, natural gas	Gm3	364	90	273	299	-
	Proven reserves, coal	Mt	6,596	5,912	1,211	7	-
	Proven reserves, uranium, 10^6 bep	10^6 bep	12,652	-	-	-	-
E-1.2	Dependence on net energy exports ("<0 %" means net exporter)	%	-6%	-178%	25%	4%	85%
E-2.1	Share of renewable energy in total final energy consumption	%	48%	32%	10%	27%	15%
	Share of renewable energy in power generation	%	82%	86%	14%	62%	12%
E-2.1bis	Installed renewable energy generation capacity	GW	144	12	24	6	1
E-2.2	Energy intensity measured on the basis of primary energy and GDP	TJ/ MUSD PPP 2017	3.9	2.4	3	2.6	2
E-2.3	Efficiency of energy conversion	%	43%	14%	43%	36%	37%
	Efficiency of energy distribution	%	79%	84%	83%	87%	85%
E-2.4	Energy intensity by sector (industrial)	TJ/ MUSD PPP 2017	8.4	3.9	3.6	2.9	2.6
	(Agricultural, fishing, and mining)		2.7	0.7	1.3	1.2	0.5
	(Services and commercial)		0.3	0.7	0.1	0.3	0.2
	(Transportation)		1.1	0.7	0.8	1.0	0.5
E-2.5	Energy intensity of the residential sector	TJ/ 1,000 inhabitants	5.3	5.1	6	4.9	5.6
E-2.6	Penetration of electricity in the transportation sector	%	0.2%	0.1%	0.2%	0.1%	0.2%
	Penetration of hydrogen in the transportation sector	%	0%	0%	0%	0%	0%

Cont'd.

49 National Sustainable Energy Transition Strategy

50 (1 – barely efficient to 5 – efficient)

Cont'd.

Number	Potential indicators	Unit	BRA	COL	MEX	PER	RDO
E-2.7	Penetration of natural gas in the transportation sector	%	2%	3%	3%	15%	19%
	Penetration of hydrogen in the transportation sector	%	0%	0%	0%	0%	0%
E-3.1	Installed capacity of stranded assets	GW	N/A	N/A	N/A	N/A	N/A
	Value of stranded assets	MUSD	N/A	N/A	N/A	N/A	N/A
E-3.2	Number of formal employees associated with existing value chains						
E-3.3	Number of jobs associated with energy transition projects (thousands of job positions)		1,272	251	82	13	0
S-1.1	Share of the population with access to electricity	%	100%	99%	100%	96%	99%
S-1.2	Share of the population whose primary source of energy is clean technologies and fuels	%	95% (2013)	92%	85%	82%	91%
S-1.4	Energy use per capita	TJ/1,000	43	27	38	27	24
S-1.5	Quality of electricity service (SAIDI)	inhabitants	17	33	21	32	116
	Quality of electricity service (SAIFI)	hours/year	12	34	0.2	15	27
S-2.1	Final residential electricity tariff	Interrup./ year	193	158			132
	Final residential electricity tariff	USD/MWh	169	191	99	242	120
	Final commercial electricity tariff	USD/MWh	171	143			196
	Final industrial electricity tariff	USD/MWh	182	107			166
	Final residential LPG tariff	USD/kg	1.3	0.9	0.94 (2018)	1.2	3.4
S-2.2	Share of household income allocated to fuels and electricity, for the total and for the 20% poorer households	%					
A-1.1	Total GHG emissions per year, total	$MtCO_2e$	1,704	280	558	198	37
	GHG emissions per year, energy	$MtCO_2e$	411	93	491	63	21
	GHG emissions per year, IPPU	$MtCO_2e$	94	10	74	7	2
	GHG emissions per year, agriculture	$MtCO_2e$	547	45	98	16	7
	GHG emissions per year, land use	$MtCO_2e$	564	111	-159	101	3
	GHG emissions per year, waste	$MtCO_2e$	89	20	54	10	4
A-1.2	Total GHG emissions per GDP unit	tCO_2e/ 1,000 USD PPP 2017	0.5	0.4	0.2	0.5	0.2
	Total GHG emissions per capita	tCO_2e/ inhabitants	8	5.6	4.5	6.0	3.4
A-2.1	Number of people directly affected, attributed to disasters per 100,000 inhabitants		210	244	73	623	N/A
A-2.2	Vulnerability and preparation for climate change		58/185	88/185	72/185	90/185	92/185
F-1.1	Cost of indebtedness of the private sector	%	7.4%	8.5%	8.5%	6.3%	7.8%
F-2.1	International financial flows towards developing countries to support research and development of clean energy	MUSD constant 2020	506.7	156.7	287.9	1.1	43.9
F-2.2	Fiscal/tax dependence on production chains associated with hydrocarbons	%	3%	12%	30%	6%	0% - NA

Source: Own preparation based on the sources described in the section "Other concepts associated with just transition".

The following indicators were gathered pursuant to the latest published information of 2022.

1. **I-2.1** Ratio of subsidies to tariffs of the sector (% GDP)
2. **I-2.2** Total expenditure on subsidies of the sector (BUSD)
3. **S-1.2** Share of the population that depends mainly on clean fuels and technologies to cook
4. **E- 3.3** Number of jobs associated with energy transition projects (thousands of job positions)
5. **S-1.4** Final residential electricity tariff (USD/MWh)
6. **A-2.2** Vulnerability and preparation for climate change

The following indicators were gathered pursuant to the latest published information of 2023.

1. **I-1.2.bis** Verification of the effectiveness of NDC[51]
2. **F-1.1** Cost of indebtedness

51 https://climateactiontracker.org/countries/

The latest information available on the indicators presented below is previous to 2019.

1. **Brazil:** share of the population whose primary source of energy consists in clean fuels and technologies (2013) and number of people directly affected, attributed to disasters per 100,000 inhabitants (2017), quality of electricity service (SAIDI and SAIFI), as published by the Inter-American Development (IADB[52]).
2. **Colombia:** data on emissions (2018), penetration of trucks running on CNG and LNG (2018), quality of electricity service (SAIDI and SAIFI), as published by the IADB.
3. **Mexico:**penetration of trucks running on CNG, LNG, and LPG (2017).
4. **Peru:** penetration of trucks running on CNG, LNG, and LPG (2013), quality of electricity service (SAIDI and SAIFI) ,as published by the IADB.
5. **Dominican Republic:** data on emissions (2010), penetration of different types of transportation (2018), quality of electricity service (SAIDI and SAIFI), as published by the IADB.

52 https://publications.iadb.org/es/impacto-de-la-regulacion-en-la-calidad-del-servicio-de-distribucion-de-la-energia-electrica-en. For Mexico, the following document was used: https://www.gob.mx/cms/uploads/attachment/file/683779/RCSEN_2019_VF.pdf

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