NDC ASPECTS

Country Report

Transition pathways for Colombia

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Andreas Meurer
German Aerospace Center (DLR)
Institute of Networked Energy Systems

Ricardo Delgado
Centro Regional de Estudios de Energía (CREE)

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Key messages

- In the light of Colombia's absolute emission target of maximal 169 $MtCO_2eq$ in 2030, the reduction in GHG emissions should become a dedicated target of actual policy instead of only being a side effect of national policies and regulations, following a clear and sustainable long-term development strategy. Economic and social development goals should be merged with environmental and climate goals.
- As the value of fossil fuel exports declines in the future, the transition to a low-carbon economy is a chance to have a positive impact on both the resilience of the economy and the reduction of greenhouse gas emissions.
- Key to a just transition is a gradual but unwavering phase-out of the fossil industry, giving time to diversify the economy, the internal consumption and the fiscal collection of taxes. Revenues from the fossil fuel industry should be used in a targeted manner to support the just and sustainable transition of the economy.

Introduction and overview

With a population of around 52 million in 2023 and a yearly increase of the population of around 1.1% in the last five years, Colombia is the second most populous country in South America after Brazil. The average growth of GDP was around 3% in the years before the Covid-19 pandemic and is expected to stabilize again at a similar level by 2025 after a backlash and reduction in 2020 [1]. The current GDP per capita is almost $7 thousand (USD). The current population growth of around 0.8% per year is expected to decrease over the next decades and turn into a decline in population by around 2050 [2]. Colombia faces a high degree of income inequality. After years of stabilization at around 35% before Covid-19, today around 40% of the population lives under the national poverty line, with around 10% living in extreme poverty [3,4].

In the year 2020, Colombia updated it's NDC, which, despite being ambitious compared to many other countries, is still considered not sufficient to meet the targets of a 1.5°C world scenario [5]. The unconditional **target of the NDC aims at national net GHG emissions below 169 $MtCO_2eq$ in 2030** which translates to a reduction of 51% to the business as usual scenario level in that year, with the **long-term target of carbon-neutrality by 2050**. It is to be highlighted that Colombia is defining the GHG emission reduction target respective to a business as usual scenario as in the former NDC from 2015 but included the resulting absolute cap in the revision of 2020, which can be considered a clear commitment of being benchmarked and thus to take action.

Development since 2015 and key topics

Despite a high share of sustainable energy in the national electricity production, fossil fuels are dominant in the final sector consumption and **the extraction of fossil energy carriers like oil, gas and coal is currently still an important pillar for Colombia's economy**. With an average contribution of around 2% on the national GDP and around 13% on the total government revenues, the export of oil remains highly important [6]. The same accounts for the role of coal, where over 90% of the domestic production is used for export, making Colombia one of the top ten world coal exporter. Nevertheless, the government plays an active role with a high commitment to climate action, aiming at a transition towards a new economic model where the revenues of the extractive industry are

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substituted by sustainable options in other sectors. A dedicated target is further a just transition [7], especially for regions affected by a coal and oil phaseout, and the protection of vulnerable communities while improving access and affordability to reliable clean energy to all. Those targets emphasize the current **major challenge of a just phase-out of fossil fuel subsidies**, which still added up to around $10 billion [8,9] between 2020 and 2022. Whereas subsidies for gasoline were already eliminated, subsidies for diesel have not been reduced yet, also because diesel is the major fuel for the public and freight transport and thus considered relevant for the reduction of inflation. Recent plans to reduce diesel subsidies led to social protests, organized mainly by the freight sector [10].

Since the introduction of the Paris Agreement (PA) in 2015, the final energy consumption grew around 6% to 1402 PJ in 2021 [11]. Final energy consumption levels where almost the same in 2015 and 2018 (the year for the latest GHG emissions inventory is available [12]. This goes along with an increase in the total national GHG gross emissions by almost 20%, from around 255 $MtCO_2eq$ to over 300 $MtCO_2eq$ (net GHG emissions were 233 $MtCO_2eq$ and 279 $MtCO_2eq$ respectively for 2015 and 2018) [13]. After decades of increasing absolute GHG emissions of the energy sector and despite the recent increase in economic activity and primary energy demand, the emission level of the sector stabilized over the last years and even started to decrease [14], varying depending on precipitation or drought conditions that conditionate the use of fossil fuels for power generation.

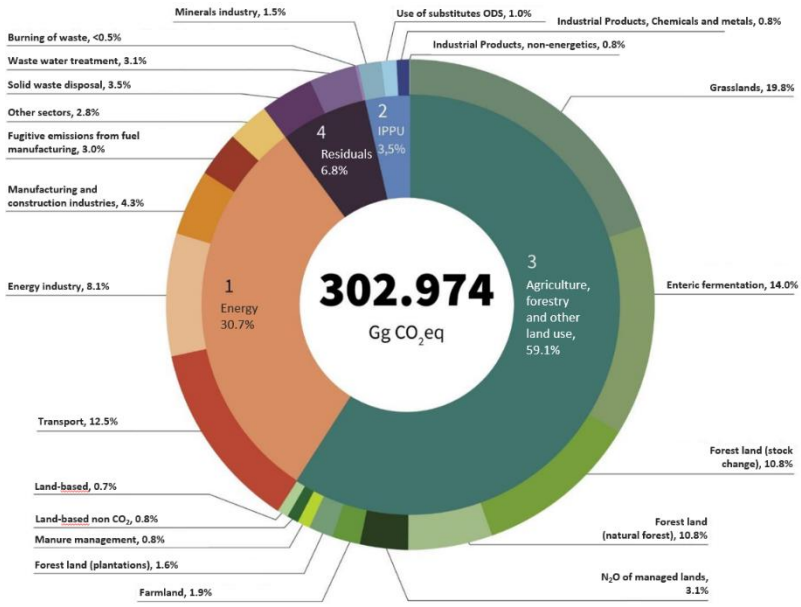

Figure 1: Annual distribution of gross GHG emissions per sector in 2018 [13]

Only around 30% of the GHG gross emissions (share increases to 33% if considering net emissions) can be accounted to the **energy sector**, from which 8.3 $MtCO_2eq$ derive from the generation of electricity and heat. The power sector, which covers the annual demand of currently around 85 TWh, is highly dominated by hydropower. The renewable share on the installed electrical capacity is around 70%. Hydropower accounts for more than 90% of the installed renewable capacities and typically generates between 65% and 80% of the required total electrical energy. Since 2015, around 35% of additional electrical capacity, both renewable and non-renewable was installed. It is expected that the non-conventional renewable share on generation capacity will be increased in the remaining of this decade. However, social and environmental licensing has undermined the development of such projects and of required power grid expansion.

The **most relevant sector for energy-related emissions is the transport sector**, with around 13% on overall GHG emissions. After an almost constant increase in transport-related emissions since 2002 and despite an ongoing increase in car stock, the emissions stabilized in the period 2016-2018, mainly due to measures such as efficiency improvements and alternative mobility concepts. With only a recent increase in the market share of battery electric vehicles, almost the entire fleet constitutes of internal combustion engines (ICE) with a share of around 47% using diesel and 44% using gasoline as fuel. It is important to highlight that there is a mandatory mix of 10% biofuels in the diesel and gasoline used in the country. As over 75% of the population lives in urban areas [7], the high share

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of ICE's does not only lead to elevated GHG emissions but also a still increasing exposure to air pollution in densely populated areas which can be linked to a significant amount of premature deaths [15].

With around 180 $MtCO_2eq$ per year, which equals to around 60% of total gross GHG emissions, **agriculture and LULUCF (Land Use, Land Use Change & Forestry) are the most emission-intensive sectors** in Colombia. The absolute emissions of LULUCF are subject to a dynamic variation in the last decades, however since the introduction of PA in 2015, the absolute emissions grew around 40%. Main contributors to the emissions are the **conversion from forest land to grassland**, the **deforestation of natural forest or excessive usage of wood from natural forests for use as fuel** and methane emissions due to **enteric fermentation in cattle farming**. The important role of deforestation as major GHG emissions contributor is also reflected in the current NDC, which specifically aims at a reduction of around 60 $MtCO_2eq$ by 2030 by reducing deforestation via a set of different measures such as via REDD+ projects or forest management strategies. Emissions from cattle farming shall be reduced via the NAMA policy for sustainable cattle ranching [16]. Despite constant improvements in the access to clean cooking fuels by around 5% over the last 10 years, still around 6% don't have access to clean cooking fuels today, with nearly 1 million families relying on wood as cooking fuel. Although the national development plan specifically addresses access to clean cooking as one of the main issues, the challenge of ensuring access and affordability of modern energy remains [6].

On the other hand, the LUCLUF sector provides the possibility to serve as carbon sink, producing negative emissions. Whereas active reforestation efforts like the **conversion of cropland, grassland, wetland or other land to natural forest** accounts for around 10% of negative emissions in average over the past years, the absorbed carbon due to **an increase in commercial forest plantation** accounts for around 90% of negative emissions [6]. During the period from 1990 to 2018, there has been a sustained increase in carbon absorption in the AFOLU sector (Agriculture, Forestry and other Land Use). In that period, the growth of absorptions has averaged an annual rate of 5.8%, reaching nearly 24 $MtCO_2eq$ in 2018.

Key decarbonization pathways & related transformations

Based on various analysis in current literature, the NDC of Colombia are ambitious but not yet consistent with the target of 1.5°C according to the Paris Agreement [5]. However, current strategies like the Long Term Strategy E2050 [7], the National Development Plan (PND) 2022-2026 [17] or the National Energy Plan (PEN) 2022-2052 [18] mainly follow the narratives and general required developments of ambitious mitigation pathways.

In addition to economy-wide decarbonization scenarios from projects such as the "Deep Decarbonization Pathways in Latin America and the Caribbean" (DDPLAC) [19] (see Figure 2 [20]), there are also various national documents targeting a long-term decarbonization.

The E2050 strategy, which was presented at COP26, outlines Colombia's plan to achieve carbon neutrality by 2050 and aims to reduce gross greenhouse gas (GHG) emissions by 90% from 2015 levels. The remaining 10% are balanced through efforts in the LULUCF sector. Key to this strategy is **transforming the LULUCF sector from a net emitter to a net carbon sink** by halting deforestation and promoting ecological restoration, potentially absorbing up to around 500 $MtCO_2eq$ per year [6]. The quantitative analysis was carried out on the basis of the integrated assessment model GCAM appended by other models like MEG4C or CAPRA. On this basis, various scenarios based on economic growth, population changes, and technology costs were developed.

The E2050 emphasizes policies for environmental education, just transition, and circular economy. It sets

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milestones for decarbonizing the economy, significantly reducing energy-related GHG emissions by 2050. Renewable energy's share in the total primary energy supply is expected to double by 2050, with solar and wind energy playing significant roles regarding additional renewable energy. The strategy includes plans for operational carbon-neutral buildings, thermal districts, self-generation, and extensive use of low-emission public transportation. By 2050, over 60% of electricity generation is projected to come from solar and wind, with hydropower providing the rest, while coal and natural gas are phased out from the electricity matrix. This configuration faces technical challenges due to requirements of ancillary services and grid constraints. These challenges are being considered in current power expansion planning and might require the use of novel technologies and further diversification of generation sources (including storage, hydrogen, geothermal, nuclear, bio-based fuels, demand response, among others).

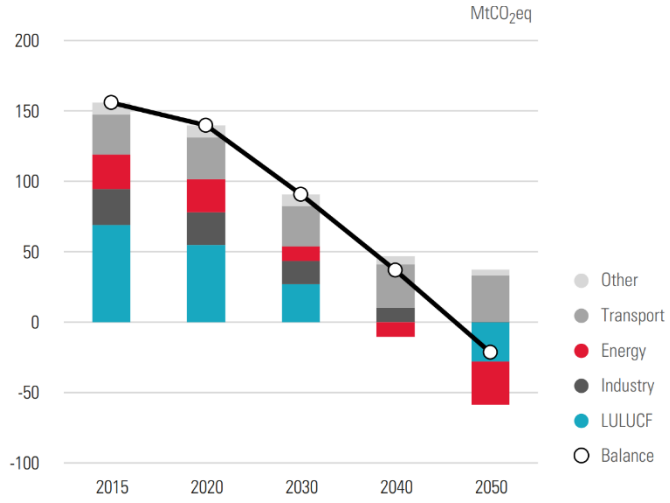

Figure 2: Annual CO_2 emissions of a possible ambitious decarbonization pathway from the DDPLAC project [20]

Complementing E2050, the PND promotes actions to close the energy access gap, improve regional equality, employment, and clean energy use. Following the PND, the National Energy Plan (PEN) is frequently adopted according to the changes in assumptions and needs of the country. As of today, latest PEN 2022-2052 is being updated. The PEN 2022-2052 targets four main pillars, security and reliability of energy supply, climate change adaption and mitigation, competitiveness and economic development as well as knowledge and innovation. Five exploratory scenarios are outlined and evaluated to describe possible pathways of the energy sector underlying different narratives. The major conclusions drawn are generally in line with the results of decarbonization scenarios in current literature.

Regarding **security and reliability of energy supply** the PEN concludes that Colombia anticipates increased energy consumption due to economic and population growth, necessitating the sustainable, efficient, and risk-managed use of resources and technology adoption. According the PEN, this requires clear energy transformation policies, alignment of hydrocarbon exploration with new technologies, and increased coverage of renewable energy, supported by community engagement. Diversifying energy generation through renewables can strengthen the electricity matrix, reduce GHG emissions, and build local capacities.

Addressing **climate change adaptation and mitigation**, the PEN concludes that emissions per consumption unit have to be lowered by implementing efficiency measures and cleaner technologies. However, implementation at a current level is not enough to achieve the commitments made for 2030 and has to be improved significantly.

While energy efficiency is considered a cost-effective and theoretically straightforward tool for energy transformation across all economic sectors and thus crucial part of **competitiveness and economic development,** there are substantial challenges to achieving the goals set out in Colombia's PROURE (Program for the Rational and Efficient Use of Energy and Non-Conventional Energy Sources). According the PEN, these challenges include insufficient investment in efficient technologies, the need for greater public awareness and education on energy conservation, and regulatory barriers that impede the large-scale implementation of energy efficiency projects. Overcoming these obstacles is essential to fulfilling Colombia's energy efficiency targets and contributing to the country's competitiveness and economic development. The transformation of the transport sector is crucial for

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ambitious scenarios and demands significant investment, infrastructure and adequate planning of the urban development. A decentralization of the energy generation via sustainable technologies can drive productive transformations, address energy access issues, postpone large infrastructure needs, and close equity gaps, requiring coordination among state institutions, academia, businesses, and communities.
It can be concluded, that the lack in NDC ambition is not subject to the absence of sketched national possible ambitious pathways as both long-term pathways from governmental institutions and literature-based scenarios provide a broad set of possible targets and measures.

Sectoral system transformations

This section summarizes some key challenges, targets and measures which may serve as enabler in the context of 1.5°C-compatible pathways towards a GHG-neutral economy for the key sectors in Colombia.

Industry

The transition from the current economy which is significantly relying on the extraction of fossil fuels is crucial to enable the necessary reduction of GHG emission on both national and global level.

- As in all decarbonization strategies, switching from fossil fuels to sustainable energy carriers in the national primary energy matrix like PV and Wind energy is a no-regret option and crucial to meet ambitious climate targets.
- A just energy transition is key to promote acceptance throughout the society for measures that might also affect the typical behavior. The necessary energy transition in Colombia can be used to decrease social imbalances by targeted investments into structurally currently underdeveloped regions.
- A reduction in fossil subsidies must take place and must take a social point of view into account. Despite the need for a rapid transition, local alternatives for jobs and revenues have to be provided.
- A progressive diversification of the Colombian economy in many fields is needed in order to reduce the dependency on revenues, taxes, job creation and exportations from fossil fuel industries at both, the national and subnational levels.
- To avoid lock-in effects or stranded assets and to improve the speed of transition, new financing of carbon-intensive technologies for attending internal energy demands should be avoided, with very few exceptions.
- Investments into environment friendly and sustainable mining activities that are required for sustainable energy technologies can provide an alternative to the fossil extraction activities. However, it should be guaranteed that mining activities do not lead to additional net deforestation.

Energy

The major challenge and target for the power sector is to serve as an enabler for the electrification of demand sectors by expanding sustainable energy generation capacities and provide a secure electricity supply.

- The diversification of the electricity matrix is key to a robust and resilient power sector in the long term, considering all available sustainable technologies, such as PV, Wind, geothermal plants and thermal powerplants using sustainable biomass (see LULUCF below) as well as the grid development and the use of technologies to provide ancillary services without requiring the use of fossil fuels.
- An extensive expansion of PV and Wind generation capacity is a no-regret option and key to a sustainable

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electricity supply. However, ongoing improvements in grid operation and stability are necessary with an increase in intermitting energy sources.

- Colombia introduced renewable energy (RE) auctions in 2019, aiming at a targeted expansion of RE capacities. To increase the attractiveness for national and international investors, RE auctions should be systematically established as a long-term mechanism [21].
- RE auctions can be used as a specific measure, to target RE investments to regions which are affected by the phase-out of the fossil fuel industry.
- Certification by social and environmental criteria are key to timely develop the renewable power generation projects as well as the required expansion of power grid infrastructure that enables the country to support the electrification of final use and the deployment of zero emissions power generation.

Transportation

Although the transport sector is the most relevant for energy related emissions and is further expected to increase, the PND does not yet address specific actions for a transition towards a sustainable mobility.

- Instead of only making financial support conditional to the promotion of sustainable mobility, sustainable transport concepts and measures should be obligatory part via legislation for relevant urban planning and construction projects.
- Holistic urban planning should guarantee a safe road space to promote substitution of car rides with manual transport modes like walking, biking etc.
- A sustainable and electrified public transport system with frequent service encourages a shift from individual to public transport. Expansion of the public transport especially in low-income areas can reduce social inequalities.
- A safe road space favors the use of lighter vehicles for individual transport. The use of light electric vehicles can save up to more than 95% of final energy required and should be promoted.
- Electrification of the transport sector brings co-benefits, especially improvements in air quality.
- Development of low or zero carbon fuels for heavy-duty long-distance freight and aviation to be used in existing fleet is required for reducing emissions in the mid-term despite the long stock turnover periods in Colombia.
- Development of multimodal freight and passenger transport infrastructure including the rehabilitation and development of rail and fluvial transport.

LULUCF

- Avoiding deforestation is key to reduce the GHG emissions of the LULUCF sector.
- The demand for biomass which will increase in ambitious pathways and possible restrictions in forest expansion and fallow land conversion due to e.g. land rights have to be considered for an assessment of the possible GHG reduction potential of those measures to avoid an overestimation of the potential.
- A strong integration of local communities in the implementation of mitigation measures affecting the LULUCF sector has to be guaranteed. Land-based measures can highly affect local communities and cause land right conflicts. If a just implementation is not guaranteed, there is a high probability that the theoretical reduction potential cannot be exploited.

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Buildings

- A conversion to clean cooking fuels via electrification of the residential sector will reduce GHG emissions and exposure to harmful air pollutants [17,18].
- Improvements in energy efficiency standards and efficient technical building equipment can reduce GHG emissions especially for public buildings [17]

Global conditions

In order to improve planning certainty for national stakeholders regarding the necessary transition to a sustainable economy, clear signals are needed at the global level regarding the future phase-out of fossil fuel extraction and industry.
International financial support, particularly for the conservation and restoration of the Amazon forest, will assist Colombia in a national transition considering equality criteria of the E2050. This includes payments for environmental services that can support farmers to protect the forest by sustainable farming and livestock practices or enables the country to invest in law enforcement to combat illegal deforestation.
As the transition away from fossil fuels is a major economic challenge for Colombia, preferential market access for alternative sustainably produced products will allow a fossil fuel-dependent economy like Colombia to replace its exports under privileged conditions.

Key messages for next NDCs

Although the current NDC revised in 2020 is not fully in line with the long-term 1.5° target of the Paris Agreement, the aimed reduction in GHG emissions of the Colombian NDC represents an ambitious pathway considering the national economic possibilities. Current insufficiencies are mainly caused by a disconnection between the stated goals and the actions in place [5].

- Current development goals, regulations and market rules were designed and adopted in a “non-climate change” context. Accounting for and attributing GHG emissions or vulnerability to climate change is a necessary step to enable targeted and effective climate action.
- The NDC should include a clear commitment to develop the necessary policy changes at sectoral level. Strategies that are clear, predictable and reliable over the long term by being anchored in the Colombian NDC will more likely encourage commitment and action by political, industrial and private stakeholders.

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References

[1] Ministro de Hacienda y Crédito Público. Marco Fiscal de Mediano Plazo 2024; 2024.

[2] DANE. Proyecciones de población, Indicadores demográficos; 2023.

[3] OECD. OECD Economic Surveys: Colombia 2022. Paris: OECD Publishing.

[4] World Bank. Poverty & Equity Brief, Latin America & the Caribbean, Colombia; 2023.

[5] Climate Analytics and NewClimate Institute. Country Summary Colombia; Available from: https://climateactiontracker.org/countries/colombia/.

[6] IEA. Colombia 2023 - Energy Policy Review; 2023.

[7] Gobierno de Colombia. E2050 Colombia, Estrategia climática de largo plazo de Colombia E2050 para cumplir con el Acuerdo de Paris; 2021.

[8] Ministry of Finance of Colombia. Press Release; Available from: https://www.minhacienda.gov.co/webcenter/portal/SaladePrensa/pages_DetalleNoticia?documentId=WCC_CLUSTER-228647.

[9] Ministry of Finance and Public Credit of Colombia. Concepto técnico: Mecanismo de estabilización diferencial para grandes consumidores de combustibles líquidos y aquellos consumidores finales que consuman en promedio anual más de 20.000 galones mes; 2023.

[10] Ministerio der Transporte - Press Release. A partir del sábado 31 de agosto se ajusta en $1.904 el precio de venta al publico del galon de acpm.

[11] UPME. BECO Consulta; Available from: https://public.tableau.com/app/profile/upme/viz/BECOCONSULTA/BECOCONSULTA.

[12] IEA. World Energy Balances Highlights 2023; 2023.

[13] IDEAM, Fundación Natura, PNUD, MADS, DNP, CANCILLERÍ. Tercer Informe Bienal de Actualización de Colombia a la Convención Marco de las Naciones Unidas para el Cambio Climático (CMNUCC. Bogotá D.C. Colombia; 2021.

[14] Energy Institute. Statistical Review of World Energy 2024; 2024.

[15] Greenpeace. Greenpeace Research Laboratories Technical Report GRL-TR-02-2021: Road Traffic Air Pollution. Bogotá, Colombia; 2021.

[16] CCAFS. Reporting 2021 Policies #821, Nationally Appropriate Mitigation Action (NAMA) for sustainable cattle ranching in Colombia; 2022.

[17] Departamento Nacional de Planeación. Plan Nacional de Desarrollo 2022-2026; 2023.

[18] Unidad de Planeación Minero-Energética. Plan Energético Nacional (PEN) 2022 – 2052; 2023.

[19] DDPLAC Consortium, Edited by C.Bataille. Policy lessons from the Deep Decarbonization Pathways in Latin America and the Caribbean Project (DDPLAC); 2020.

[20] DDPLAC Consortium, Edited by C.Bataille. Policy lessons from the Deep Decarbonization Pathways in Latin America and the Caribbean Project (DDPLAC): Supplementary material: standard graphics of scenario results (DDPLAC); 2020.

[21] IRENA and USAID. Renewable energy auctions in Colombia: Context, design and results. Abu Dhabi; 2021.

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Corresponding Author

Dipl.-Ing. Andreas Meurer
andreas.meurer@dlr.de

PARTICIPANTS

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