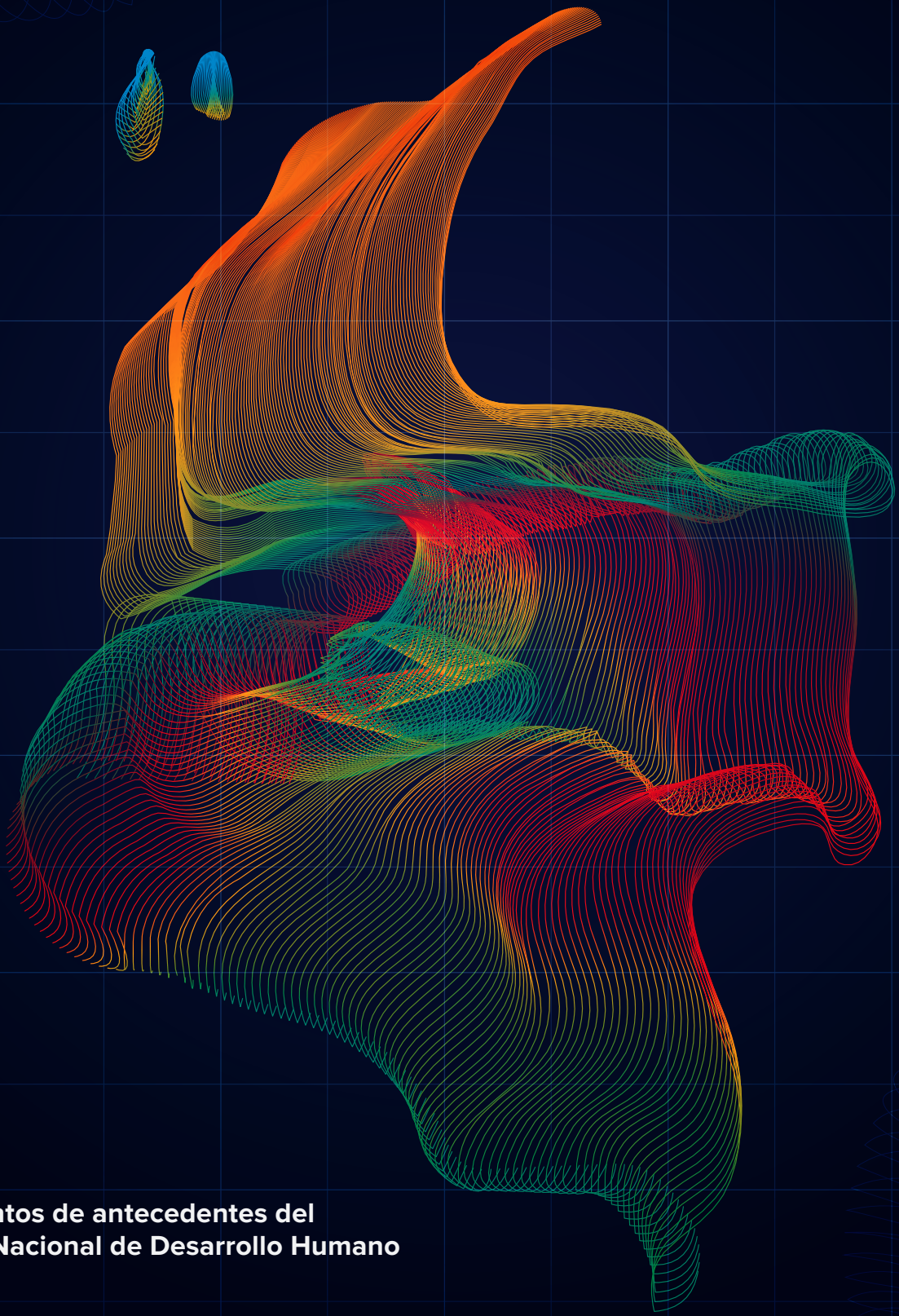
# Colombia's just energy Transition. A People-Centred Cost-Benefit Analysis



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# Colombia's just energy Transition

A People-Centred Cost Benefit Analysis

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A People-Centred Cost-Benefit Analysis

The purpose of this paper is to understand how a fair, sustainable, efficient, and inclusive energy transition can be carried out in Colombia by, at the same time, mitigating, avoiding, and addressing inequalities in human development. This was assessed through the development of a cost benefit analysis that sought to quantify the positive and negative impacts associated with the energy transition. Our analysis revealed that the most significant areas of focus in an energy transition should be how the energy transition will affect the livelihoods of Colombians through potential losses in jobs, the impact to culture, the effects on the environment and health, and revenues related to royalties. It is recommended to apply a people centric lens to policy actions related to the energy transition.

**Keywords:** Colombia, just transition, people-centred, cost effective, energy policy, indigenous rights, coal mining, oil extraction

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**Abbreviations**

| | |
|---|---|
| AFOLU | Agriculture, Forestry, and Other Land Use |
| BAU | Business as Usual |
| BOE | Barrels of Equivalent Oil |
| CBA | Cost Benefit Analysis |
| COP | Colombian Peso |
| DANE | National Administration Department of Statistics |
| FPIC | Free, Prior, and Informed Consent |
| GCMC | Generational Coal Mining Communities |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gases |
| LAC | Latin America and the Caribbean |
| MME | Ministry of Mines and Energy |
| NDC | Nationally Determined Contributions |
| OECD | Organisation for Economic Co-operation and Development |
| O&G | Oil and Gas |
| PPP | Purchasing Power Parity |
| R&D | Research and Development |
| SMSE | Small and Medium Sized Enterprises |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environmental Program |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USD | United States Dollar |
| VSL | Value of Statistical Life |

## Executive Summary

As countries globally begin to assess how the energy transition will be carried out, there are barriers, opportunities, and social challenges that must be considered on a country-by-country basis. Colombia is not a particularly carbon-intense economy, as it emits 0.59% of global GHG and its share of global output is 0.54%. Its electricity matrix is one of the cleanest, with 70% of electricity coming from hydro-power. The country does depend economically on resources from fossil fuels. Oil, gas and carbon extraction activity has generated significant tax revenues, royalties, and other contributions during the last decades that have allowed an increased level of social investment. The sector accounts directly for around 7% of GHG emissions, while AFOLU accounts for 44%, within it deforestation 16% of total, with a similar share for road transportation. The commitment to the energy transition in Colombia poses both challenges and opportunities. A full transition away from the production of these fossil fuels will mean a loss of up to 100,000 direct and indirect jobs, up to 3% of GDP in fiscal revenues and royalties, among other economic and social costs. The study proposes a cost-benefit model to account for these trade-offs and maps the transition at different speeds and across regions with a 25-year horizon.

The distribution of these losses indicates that populations in more vulnerable areas stand to lose disproportionately more from the job loss and associated public expenditure reduction. Conversely, the health, social, climate and environmental benefits can outweigh the costs in a minority of regions. Those who stand to win from the transition because of their exposure to climate risks are often underrepresented. On aggregate, the costs identified are not fully compensated within the model, which is limited by the extent to which benefits could be monetised. A central insight from the model is that the pace of the transition is a major policy decision, as the accumulated trade-offs increase significantly the faster and sooner the phase-out. The policy challenge posed by an expedited or extreme transition would need several fiscal, labour, environmental and regulatory reforms beyond the state's capacity.

The report presents a characterisation of Colombia's environmental, economic and social profile, followed by the results of the cost-benefit model with a particular focus on the distribution of impacts to assess the justice of the transition, leading to the policy implications. From the characterisation and model results, the report lays out three sets of recommendations: (i) About the pace of the transition; (ii) On reducing trade-offs and ensuring justice in the transition; and (iii) Achieving an effective transition.

**Recommendation 1: Divest from extractive industries at a moderate pace to minimize premature job and revenue loss.**

Different transition paces will result in vastly different costs associated regarding job loss and government revenue, which entails even further pressure for the economy to adapt. To minimise job losses and ensure social equity while still complying to Colombia's net zero commitments, the transition must be managed at a pace that gives the Colombian job market time to absorb the changes. In addition, it gives time to ensure funds can be reallocated in such a way that social services and programs can adapt to decreased funding without impacting the people's wellbeing.

**Recommendation 2: Re-investing royalty revenue from coal production.**

Supporting existing energy transition initiatives approaches by reinvesting the currently high coal and oil royalties driven by international prices would promote stable financing. Low royalties revenues driven by the transition in the future will mainly affect poor and vulnerable areas, with a large fraction of indigenous population. Reallocating the current spending towards renewable technology would result in lower costs associated with the transition.

**Recommendation 3: Encourage a dialogue process between communities, mining companies, and the government to ensure needs are met.**

A fair impact distribution requires dialogue between all stakeholders. Vulnerable communities require particular attention should be given for vulnerable communities, which include indigenous populations and communities highly-dependant on fossil fuels. The government must increase existing regulation to ensure to recognize and address

concerns of all communities is met. Consultation processes are unsatisfactory so far, as communities often find that extractive activities proceed despite significant pushback (Iseli, 2020). Clearer regulatory measures, legal frameworks, and enforcement mechanisms are needed.

**Recommendation 4: Leverage existing capacities and economic diversification to offer training and reemployment alternatives.**

Given the low linkages of mining, the main challenge is providing adequate support for the coal, oil and gas workers of the closing extraction sites and the surrounding communities. Training and reemployment must be proactively offered by leveraging on already existing mining-targeted programs, their ongoing economic diversification into hydrogen, and partnerships with companies and universities. Additional targeted measures could be provided subject to a successful diversification of fiscal income.

**Recommendation 5: Diversify Colombia's fiscal income sources to mitigate the loss of revenue trade-offs from the transition.**

The biggest cost to such a transition are fiscal revenues. Fiscal diversification has two avenues: (i) Replacing the existing revenues and rents with new activities and (ii) Extending the tax base. Hydrogen is the most attractive option to replace revenues, but its potential is still uncertain. For (ii), Cardenas & Orzoco (2022) highlight Carbon Pricing, Green Fiscal Rules and Carbon Offset Markets.

**Recommendation 6: Address the most significant polluting sectors to ensure an effective decarbonisation.**

Addressing AFOLU emissions, and specifically those coming from deforestation, through the establishment of Carbon Offset Markets, enforcement of land management and expanding ecological restoration, is likely most cost-effective alternative for net zero, as it as dual environmental/climate and fiscal benefits. Another cost-effective alternative strategy is electrification of transport and residential, leveraging from Colombia's existing clean electricity matrix.

# 1 Introduction

As Colombia considers an energy transition to facilitate decarbonisation and ensure a more sustainable future, it is essential to consider the unique and significant costs and benefits of a 'just' transition. This report seeks to underscore not only the costly nature of transitions, but how these costs and benefits are inherently unevenly distributed across regions, communities, industries, and individuals. In doing so, it analyses Colombia's transition putting the people of Colombia at the centre. To ensure a smooth and equitable energy transition for the population, it is crucial to understand Colombia's specific economic, social, and environmental context, tailoring policy accordingly. Therefore, as a first step, the report documents the relevant literature and established frameworks to define the 'just' energy transition concept. Followed by an analysis of Colombia and the costs and benefits of the transition, with a focus on the impacts on the people, breaking down these costs and benefits by region, gender, socioeconomic status, and ethnicity. A people-centred approach is the defining feature of this analysis. This distinguishes it from existing macroeconomic studies, offering a new perspective on how a 'just' energy transition can occur in Colombia and its effects on its population.

# 2 Background

## 2.1 Defining ‘Just’ Transition

Defining what a 'just' transition is crucial, as it determines the goal of the analysis. A vast number of relevant definitions can be found in the literature. Scholars Heffron and McCauley (2017) discuss this, illustrating three different research areas with competing definitions: energy justice, climate justice, and environmental justice. They define climate justice as the concerns surrounding both the benefits and burdens of climate change from a human rights perspective; energy justice as the application of human rights; and environmental justice as the goal to treat all individuals equally and involve them in the "development, implementation and enforcement of environmental laws, regulations and policies". UNDP aptly defined environmental justice as seeking "the equitable treatment and involvement of people of all races, cultures, nations, and socioeconomic backgrounds in the development, implementation, and enforcement of environmental programs, laws and policies" (Allen, 2022, p. 13). Environmental justice requires the introduction of a legal framework to protect environmental rights and facilitate climate equity. Ultimately, an amalgamation of all these definitions is needed to adequately account for the nuances of how humans are affected by the energy transition.

The interconnected nature of biodiversity loss, ecosystem loss, and increased pollution act as multipliers to existing crises including "amplifying conflicts, tensions and structural inequalities, and forcing people into increasingly vulnerable situations" (Allen, 2022, p. 5). According to Carley and Konisky (2020), energy justice is “centred around the notion that all individuals should have access to energy that is affordable, safe, sustainable, and the opportunity to participate in and lead energy decision-making processes with the authority to make a change”. Here we see four key features of energy justice: access, affordability, sustainability, and inclusion. A just transition requires marginalized individuals and communities’ voices and stories to be central to policymaking. This core philosophy is bolstered by the findings of Roth, Dufour, and

Gencsu (2022) who underscore the intersectionality of energy transition policy in affecting poverty and inequality. Carley and Konisky (2020) explore three core tenets of climate justice that can be useful in ensuring a just transition in Colombia. They discuss the need for distributional justice – the distribution of benefits and burdens across populations, procedural justice – who is included in the energy decision-making processes, and recognition justice – the need to understand historic and persisting inequalities and how to reconcile them (Carley and Konisky, 2020, p. 570). These intersecting avenues for justice must also acknowledge intergenerational equity, as well as between regions and communities (Allen, 2022, p. 14). It is important to note that sustainability is a necessary condition for justice, as we see environmental degradation and climate change marginalizing vulnerable communities and worsening existing inequalities.

For the purposes of this report, we will be understanding a just transition as one that places people and their needs at the centre of the transition. It will consider access, affordability, sustainability, as well as inclusion of individuals and communities most affected in the decision-making processes. Additionally, it will be cognisant of the unequal distribution of both the costs and benefits of energy transition, including social policy to make this energy transformation as fair and equitable as possible.

## 2.2 Cost, Benefits and Trade-offs of the Energy Transition

### 2.2.1 The Global Experience

As climate change has become one of the most urgent issues in the global sphere, many countries are required to find ways to significantly limit the amount of greenhouse gas emissions. The energy transition includes two simultaneous approaches; adapting greener technologies and phasing out the use of fossil fuels (Rentier et al., 2019). Countries face different costs and benefits in due to differences in economic structures, political situations, and energy and emissions matrix.

Germany initially tried to increase the share of less carbon-based technology in electricity generation, but from 1990 to 2015 renewable electricity only grew 171 TWh

a year. Throughout the same period (1990 to 2017), the use of coal only went down by 38TWh annually. This is partly related to the ‘coal lock-in' effect-the degree to which the country is relying on the coal industry, since the coal-fired power plants, which provide almost 46% of the electricity in Germany, employ 35,000 people, any divestment could pose huge economic and political burdens (Parra et al., 2019). Moreover, Germany’s ambitious “Energiewende” plan in 2010 included early action plans to massively expand renewable electricity. However, due to exorbitant direct costs, there has been bringing scepticism about the feasibility of the plan. Even if the plan is successful, the question remains if other countries can bare the same financial burden (Unnerstall, 2017). The experience of emerging economies has also shown that a transition in fossil-fuel-dependent economies could lead to a considerable loss of revenues and strong community resistance (Huxham et al., 2019; UNEP/SEI, 2020). These costs will increase if the transition is enacted without proper preparation and cooperation of stakeholders. In China, the central government enacted a heavy top-down approach. This fostered massive inefficiencies due to information gaps between the local and central governments, which resulted in a failure to provide proper support for local workers with endangered jobs (Wang et al., 2018).

Some studies have shown that technological innovation can have a significant effect on sustainable development (Wilson et al., 2019). In Norway, energy firms integrated long-term planning, specifically related to supply chain management and technology development to align with decarbonisation goals (Koasidis et al., 2020; Formentini and Taticchi, 2016). Demonstrating additional efforts such as R&D or innovation can help advance the transition and mitigate negative impacts. Further indicating that a just transition can be achieved and sustained with considerate planning and support from stakeholders.

### 2.2.2 The Energy Transition in Latin America

The transition in Latin America is quite distinct from other parts of the world in that it can bring significant economic benefits to the region. Latin America has many critical minerals for decarbonisation, such as lithium, manganese, nickel, copper, and

rare earth elements (Lebdioui, 2022). This brings an enormous potential of placing the region as a crucial exporter.

One of the most striking effects of the energy transition is the shift in the region's job scenario, which will occur along with the ongoing labour market challenges. Social security and unemployment benefits are still insufficient despite the efforts to increase coverage. The region suffers from high inequality, which is persistent in the labour market and primarily affects Indigenous groups and women. Moreover, informality is pervasive, with an average share close to 50% and values of over 80% in lower-middle- income countries such as Bolivia, Guatemala, Honduras and Nicaragua (Saget, Vogt- Schilb, & Luu, 2020). These characteristics imply several region-specific challenges to carrying out a decarbonisation transition in LAC.

The transition could entail net job creation, particularly in countries with the most considerably developed supply chain of technology for renewable energy, such as Mexico and Brazil (ECLAC, 2022; Saget et al., 2020). However, net figures mask potential challenges, such as reallocation, reskilling, and lower wages (Saget et al., 2020). Most jobs expected to be created due to the decarbonisation process are concentrated among low- and medium-skilled occupations, while net job destruction is expected for high-skilled levels (ECLAC, 2022). Even if jobs can be created in the same location, the quality of life for affected workers still risks deteriorating.

Decarbonisation in LAC creates an opportunity to address gender gap and informality in the region. While this is an opportunity for the emergence of new job programs that tailor these issues, this could also be enabled simply by expanding current programs. For example, the Bolivian "Program for the Support of Employment", which provides jobseekers incentives to attain formal employment experience, has shown overall positive results that turn out to be more pronounced for women than men (Novella & Valencia, 2019). In Latin America, full-time positions in small firms are more typically filled by women than men (ILO, 2017). Boosting micro, small and medium-sized enterprises (MSMEs) with clean and affordable energy has the potential to directly benefit women workers.

Decarbonisation poses risks to the region's economic and political stability. Historically, attempts to promote efficient use of fuel resources, through the removal of fossil-fuel subsidies have been associated with red tape and social disruptions, including costly and violent strikes and riots (Lopez-Marina, 2022; The Economist, 2022). Similarly, decarbonisation strategies have resulted in strikes driven by affected workers (diarioUChile, 2022; Sindical, 2021).

Fiscal health can also be highly jeopardized by the countries' domestic decarbonisation efforts. The region currently holds one-fifth of the global proven oil reserves, mainly distributed in Venezuela, Brazil, Mexico, Ecuador, Argentina, and Colombia. The dependence on this fuel is particularly pronounced in Venezuela, Trinidad & Tobago, Mexico and Ecuador, where the oil industry is a relevant source of jobs and fiscal income (Solano-Rodriguez et al., 2019). Constraining the exploration and production of fossil fuels will result in significant adversities and macroeconomic challenges among oil-exporting countries, especially those with low-diversified economies. While this is a challenge for all oil-exporting countries in the world, LAC countries have lower capacity, less political space for reaction, and fewer funds to account for these challenges (Stanley, 2020)

Even if fossil-fuel exporting countries in LAC decide not to decarbonise, they will face uncertainty as the world switches towards renewable sources and away from fossil fuels (Solano-Rodriguez et al., 2019). The uncertainty surrounding future fossil-fuel demand calls for anticipatory planning and long-term strategic vision. For instance, considering existing policies backed by legislation, the IEA (2022) expects global oil demand to peak during the mid-2030s. If global demand is consistent with the 1.5°C target, 60-80% of oil reserves in LAC will be unused by 2035, threatening jobs and reducing fiscal revenues by half (Solano-Rodriguez et al., 2019). Incentivising the diversification of fiscal revenues away from fossil fuels will be key to ensuring a sustainable fiscal income (Solano-Rodriguez et al., 2019; Stanley, 2020).

### 2.2.3 Colombia's Steps Towards an Energy Transition

Colombia's electric matrix is considered one of the cleanest in the world, producing 70% of its electricity with hydro resources, while the rest comes from natural gas and coal. It also has significant potential for other renewable energies –such as solar, wind and geothermal. This offers an opportunity to ensure a clean matrix expansion, especially as the economy electrifies (Ministerio de Minas y Energía, 2022). Completely removing fossil fuels could increase electricity prices and harm energy security (Fedesarrollo, 2022). Thus, the government has discarded an accelerated decommission of fossil-fuels for electricity generation (Semana, 2022). In fact, a gradual transition with natural gas as a bridging fuel has been underscored as key to guaranteeing the system's stability (Ministerio de Minas y Energía, 2022).

The transition could bring high costs associated with job losses, primarily from mining and fuel production workers. The mining and energy sector in Colombia employs around 350,000 people. These workers tend to be highly qualified and earn a much higher salary than those in other sectors. However, they only correspond to a low fraction (1.8%) relative to other sectors (Ministerio de Ambiente y Desarrollo Sostenible, 2020). The main risk associated with job loss in Colombia is the dependence of certain regions on carbon-intensive activities. This entails a disproportionate effect of the transition in specific areas, augmenting the risk of social discontent and disruptions.

The transition provides opportunities to improve people's lives in the same communities affected by job losses. There seems to be a chronic imbalance between fossil fuel-related projects and social welfare, evidenced by multiple allegations associated with minority group displacement and lack of social justice (Vega-Araújo & Heffron, 2022). By setting the right goals and procedures, the energy transition could spur social justice and economic development in neglected areas. There is an opportunity to incorporate indigenous groups in the decisions and changes the transition implies (Ministerio de Minas y Energía, 2022).

The main inputs guiding the transition in Colombia are: (i) The “Hoja de Ruta” document by the Colombian government (MME, 2022), which outlines the policy objectives and motivations of the current government, emphasizing the intersectionality of climate justice and the need for representation of the most vulnerable; (ii) The prior government's policy imprint in a joint report with the IDB (MME, 2021), which outlines more market-oriented policies, such as incentives, laying out frameworks to foster renewable markets and infrastructure. (iii) The technocratic planning body’s framework for the implementation and challenges of the transition in Colombia (CONPES, 2022);
(iv) Reports that adopt a cost-benefit framework to assess different transition paths in (Fedesarrollo,2022), which advocates for the non-divestment in current energy assets but rather policies and investment to make renewables more profitable, and (IDB, 2022) which develop a similar CBA model to the one proposed here, but at an aggregate level and estimating high-level mitigation costs necessary to achieve carbon neutrality by 2050, and the associated benefits; and finally, (v) Other partial impact analysis, of economic nature, such as the macro-fiscal and currency impacts of reducing fossil fuel production (ACP, 2022; Corficolombiana ,2022); and Fedesarrollo, 2021).

## 2.3 Strategies for a Just Energy Transition

The international experience has shown successful transitions come from long-term commitments to public spending, pricing reform, and minimizing unwanted distributional impacts (Barbier, 2020). As the energy transition inevitably leads to a drastic change to the workers, households, and the entire country, the government must seek solutions with the civil society to make a sustainable transition. Table 2-1 condenses the key strategies of a just transition according to the international experience. A longer version with relevant examples can be found in Appendix E.

**Table 2-1. Key Strategies for a Just Transition**

| Strategy | Insight |
|---|---|
| **Targeted programs** | Programs designed in consultation with stakeholders and targeting affected groups can mitigate the negative consequences of the transition and foster people's support. |
| **Active job reallocation** | The interaction between the government and the private sector is crucial in delivering tangible solutions for the workers. Avoiding the negative impacts of the transition will require providing job alternatives that translate into better working conditions for the affected communities |
| **Skill development** | Skills creation requires the cooperation of stakeholders to identify new occupations, implement training programs that address skill gaps, and support workers in transitioning through upskilling and reskilling. Adapting general education at the university and school level is crucial to developing flexible workers with cross-cutting skills. To avoid biases, it is vital to identify clusters of affected individuals beyond highly educated and labour market-attached workers. |
| **Addressing the gender gap and informality** | The transition poses an opportunity to create programs that promote the participation of underrepresented groups and reduce informality. This requires creating programs that encourage commitment from relevant stakeholders. |
| **Foster innovation and investment** | Creating economic opportunities is critical to absorb the job loss and ensure financial health. Exploring new market opportunities and promoting investment requires a sound policy framework in line with the country's comparative advantages and energy trends. |
| **Supporting the community** | The disproportionately damaged communities need to be identified and compensated in ways that foster a permanent improvement of life quality. |

Source: Own work

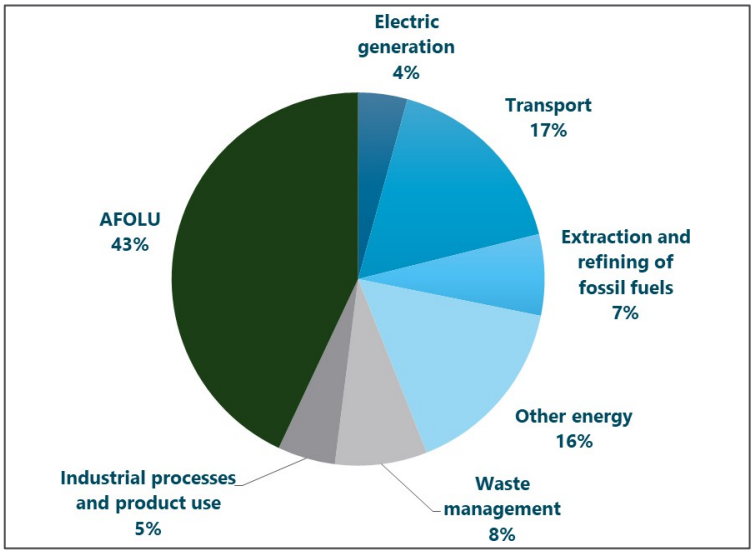
# 3 Characterization of Colombia

## 3.1 Greenhouse Gas (GHG) Emissions

**Colombia accounts for a small amount of global GHG emissions.**

Colombia represents 0.59% of global economic output and accounts for only 0.54% of global GHG emissions. This places Colombia as a low-emission country. Comparatively, Argentina has 20% more economic output while double the Colombian emissions. The Colombian electricity grid is among the cleanest in the world, with hydroelectric power accounting for 70% of its electricity production. As shown in Figure 3-1, Colombia is a low contributor to GHG emissions (4%). Similarly, as a fossil fuel exporter, Colombia's economy depends much on the extraction and refining of coal, oil and gas. However, this activity only entails 7% of the total GHG emissions. In contrast, a considerable part of Colombia's emissions come from agriculture, forestry, and other land use (AFOLU).

**Figure 3-1. Greenhouse Gas Emissions in Colombia**




Source: Minambiente (2017). Own work

**AFOLU is one of the biggest emitting sectors, with deforestation and agriculture accounting for 27% of total emissions.**

The biggest polluters in AFOLU (Figure 3-2) are the change of land use from forest to pasture and others (i.e., deforestation) (35.8%) and the methane coming from farm animals' digestion (i.e., enteric fermentation) (27.6%). Deforestation in Colombia is the most significant carbon emission activity, therefore, policies addressing deforestation are crucial to achieving net zero. Such policies have the dual environmental benefit of helping preserve biodiversity, one of the main reasons why Colombia is particularly vulnerable to climate change.

**Figure 3-2. Greenhouse Gas Emissions from AFOLU**


Source: Minambiente (2017). Own work

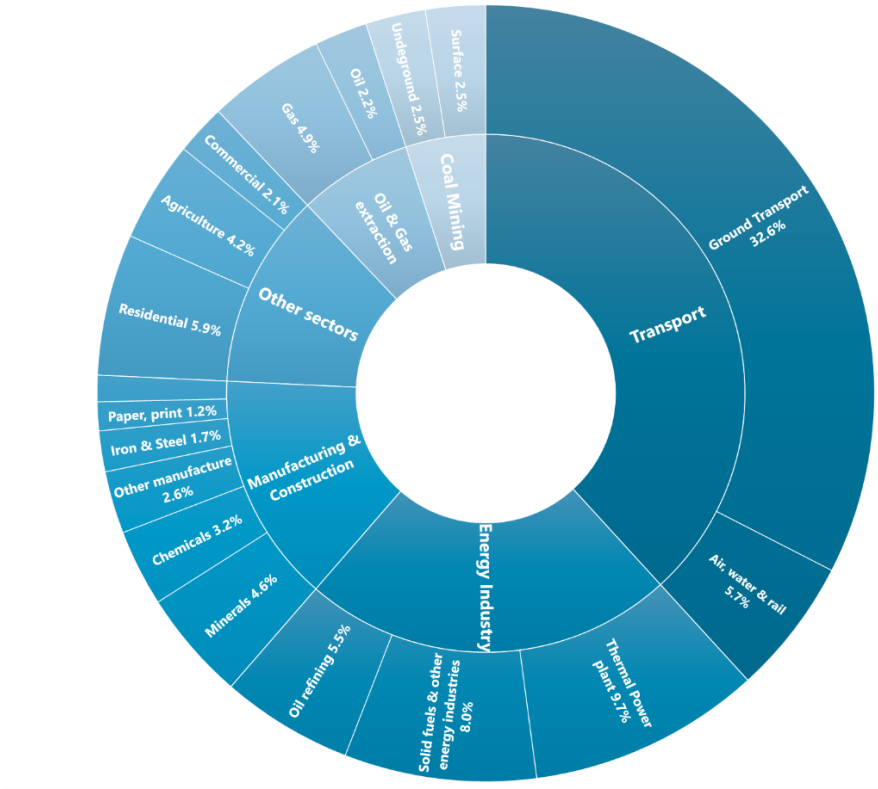
**The fossil fuel production sector has been highly debated as a key area for energy transition, although it accounts for only 7% of total emissions.**

Within energy (Figure 3-3), the most polluting sectors are those based on fossil fuel combustion. Namely, transport (38.2%) – mainly ground transport (32.6%) –,

electricity generation (23.1%), manufacturing (12.2%), and oil and gas extraction and coal mining (12%). There is an opportunity to address inefficiencies, as 47% of the consumed energy is lost due to inefficiencies, especially at the residential level (Ministerio de Minas y Energía, 2022). Higher efficiency can be driven at the residential level by upgrading electric appliances and implementing demand-side management to impulse behavioural changes (EIA, 2022). At the transport level, energy efficiency improvements can be underpinned by stringent fuel economy standards (EIA, 2022).

The current policy debate has mainly drifted to the actionable role of oil and gas and coal**,** which comprise a non-negligible 7.1% of total GHG emissions (Ministerio de Minas y Energía, 2022). As will be discussed at length, a transition from fossil fuel extraction implies considerable trade-offs.

**Figure 3-3. Greenhouse Gas Emissions from Direct Energy**




Source: Minambiente (2017). Own work

## 3.2 Macro Costs: Accounting for the Size of the Impact

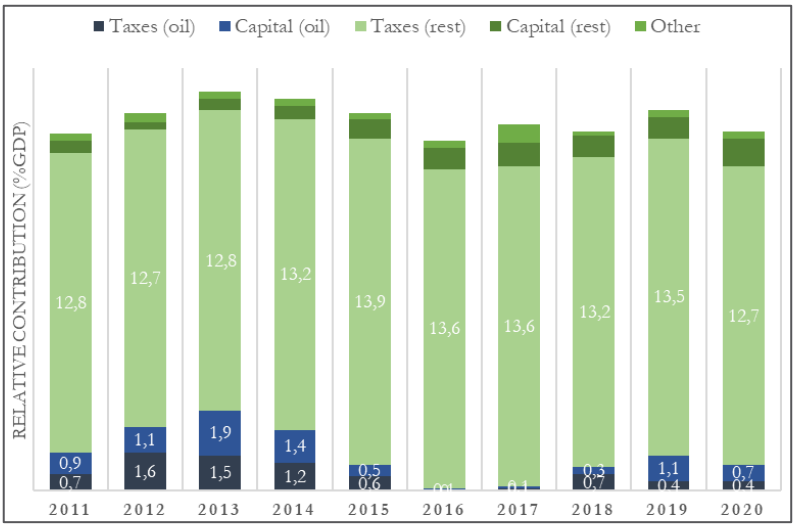
**Colombia's economy highly depends on oil and coal for energy and fiscal revenue.**

In 2021, Colombia was South America's largest coal producer and the second-largest petroleum producer (EIA, 2022). This makes its economy highly exposed to the international price of these products and implies a significant economic barrier associated with substituting these fuels. Consequently, the decarbonisation process can be understood as an opportunity to diversify the origins of fiscal revenue, moving from extractive to productive activities (Ministerio de Minas y Energía, 2022).

During the last decade, Ecopetrol's profits and taxes paid averaged 1.53% of GDP, equivalent to an average of 9.5% of the central government's revenue during the period (Fedesarrollo, 2021). From 2021 to 2022, Ecopetrol sustained record profits and

provided an additional 6.6 billion COP to the central government in 2022, for a total of 16.3 billion COP of capital revenue and approximately 14.5 billion COP of tax revenue (MTFF Colombia, 2022). Ecopetrol produced 736,397 boe/d[1] in 2021, sold at an average price of 70.68 USD - and is expected to increase production to around 760,000 boe/d in 2022. Therefore, every 10,000 boe/d represents 0.4 billion COP of revenue for the Colombian government – approximately 0.2% of central government revenue, on average.

**Figure 3-4. Central Government Revenue Decomposition (as a share of GDP)**




Source:. Ministerio de Hacienda.Own work

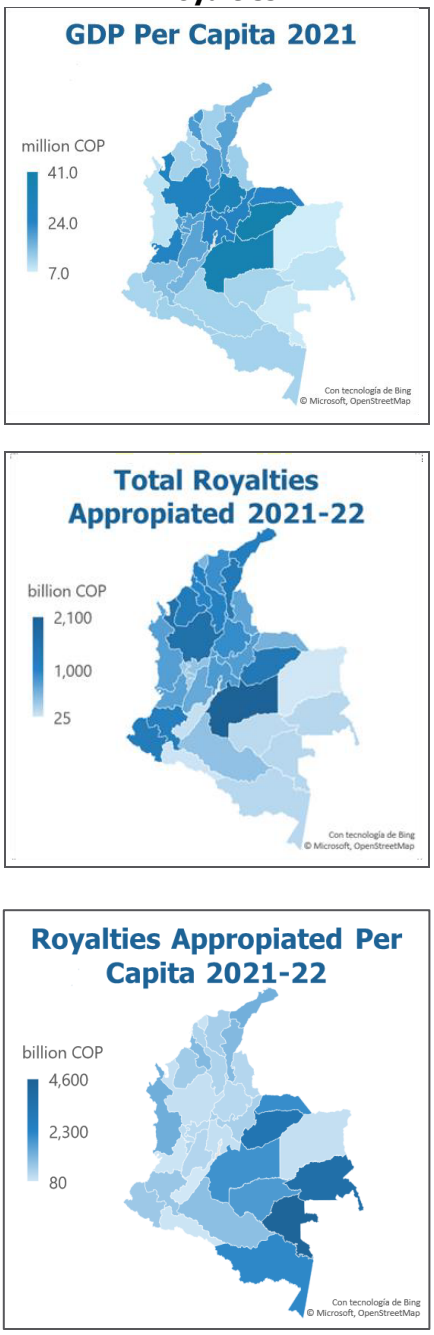
[1] Barrels of oil equivalent per day

**Phasing-out extractive industries will alter the composition of funds for local governments, risking worsening regional inequality.**

In addition to Ecopetrol's profits, extractive industries'[2] royalties are distributed by the Royalties System (SGR)[3] directly to subnational governments. The distribution follows a series of guidelines, including earmarks for expenditure in certain areas and a regional compensation fund. Over time, the extent to which producing departments are prioritized has varied with different reforms. In 2021, the total budget allocations from royalties were 9.6 billion COP, from which the Cesar, Antioquia, Nariño and Cordoba Departments were allocated 30% of the budget. These funds are particularly important because they shape regional development and influence the patterns of regional inequality. How the royalties are distributed is a point of contention, as the producing regions sometimes overlap with the poorest ones (such as La Guajira).

Given the characterisation of the royalties' distribution, it is hard to claim that lower production would lead to a disproportionately negative effect on lower-income or producing Departments. For example, Bogotá DC, the capital and the highest income area, has just 0.2 billion COP less allocated than La Guajira. Nonetheless, the numbers tell a

**Figure 3-5. Distribution of Royalties**




Source: DANE. Own work.

[2] Oil, mining, and any activity that extracts a finite resource from the soil, which belongs to the State.

[3] SGR – Sistema General de Regalias

different story when considering the per capita allocations and possible reductions relative to income levels. La Guajira receives 547,992 COP per capita, with an average income of 14.9 million. Bogotá DC receives 65,981 COP per capita, with an average income of 38.5 million. Suppose royalties are reduced by 10% (in total and on departmental allocation). This would mean a 0.36% loss of average income for La Guajira, and only 0.01% for Bogotá DC.

The institutional framework of the Royalties System (SRG) is separate from that of the general budget (SGP) and is more conducive towards redistribution. Therefore, even if the reduced output of extractive industries was replaced by another economic activity, the composition of funds available to regional and local governments would still be considerably altered, exacerbating regional inequality in Colombia.

**Fossil fuel extraction revenue enables the government to run poverty reduction services and programmes.**

Although seemingly a macro issue, the availability of government revenue will have massive micro implications. Paradoxically, the slower the phase-out of fossil fuel extraction, the more funds are available to carry a successful transition. A rapid phase-out of fossil fuels will make it harder for local governments to find the resources to diversify their economy and mitigate the costs associated with the transition. Furthermore, revenues from extractive industries have allowed for expanding public investment and funding social programmes for poverty reduction.

Similarly, adaptation measures also require financing. Colombia is the tenth most vulnerable country to the effects of climate change globally, has the highest incidence of extreme weather events in the region, and over 80% of its people and assets are exposed to hazards such as flooding and landslides (World Bank, 2021)

Secondly, the earmarked royalties' allocations for health and education in regional governments have been a significant source of levelling up in terms of access to these services and have been critical in the multidimensional poverty reductions of this century. If Colombia fails to replace the source of income and the fiscally decentralised

mechanism, public services, such as hospitals and schools, will face the risk of further lacking the funding to provide an adequate service.

**Decreasing fossil fuel exports would have a detrimental effect in international trading.**

Another relevant macroeconomic cost is the reduced currency influx, mainly of USD. Oil exports are the largest foreign currency source in Colombia's real sector, and a rapid contraction of exports would have a significant impact on the exchange rate. Corficolombiana (2022) estimated the exchange rate and balance of trade effects of two scenarios, one with stable production until 2030 and another with a steady decline. The outcome was an additional devaluation of around 40% to 44%, which could take the USD to equal 7,000 COP[4]. The trade imbalance could drop as much as 38.8%, along with reduced imports by up to 8.9%.

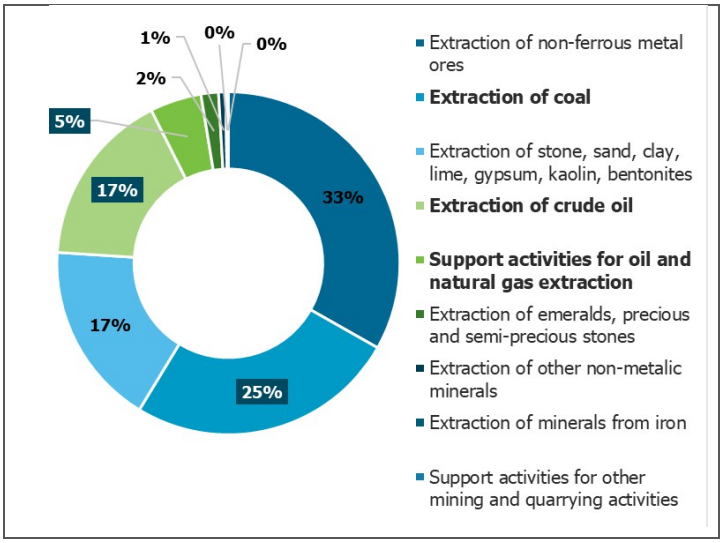
[4] The analysis was done prior to the global monetary tightening in mid-late 2022, which has seen most emerging market currencies heavily devaluate against the dollar.

## 3.3 Micro Costs: A People-Centred Approach

**The value added by jobs in mining implies a significant toll on the labour force due to the phasing-out of fossil fuel extraction.**

Colombia has an unemployment rate of 13.7%, which has maintained relatively stagnant over the years. An underemployment rate of 25% and an informality rate of 25% and 58% (DANE, 2023). Mining activities accounted for about 206,000 jobs [5] , distributed as shown in Figure 3-6. Nonetheless, the distribution by value-added looks very different, as some activities are less labour intensive, more productive, more formal, and may have the employment share only partially estimated.

**Figure 3-6. Employment in Mining Activities**



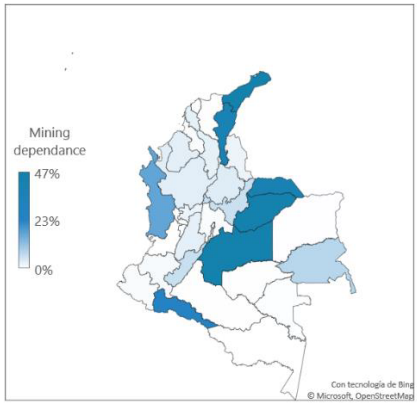

Source: DANE. Own work. Note: highlighted are the activities in which the analysis is focused

Although mining activities employ only 1% of the total workforce, it is one of the few sectors with overwhelmingly formal employment and that mainly operates outside the leading economic centres. As shown in Figure 3-7, it is concentrated in specific departments and is the primary source of employment in certain small municipalities. The most mining-dependant regional economies are Meta, La Guajira, Casanare, Arauca, Cesar and Chocó. Therefore, a rapid reduction in mining activities would be particularly costly to people in these areas.

[5] This figure is underestimated. The data source (Gran Encuesta Integrada de Hogares – GEIH) only covers the largest municipalities in each department, and excludes Amazonas, Arauca, Casanare, Guainía, Guaviare, Putumayo, Vaupés, Vichada and San Andrés. It is therefore subject to overlook jobs in crude oil, which happens in more remote areas.

**Jobs lost will be concentrated in poorer and more vulnerable departments.**

**Figure 3-7. Mining Dependence**

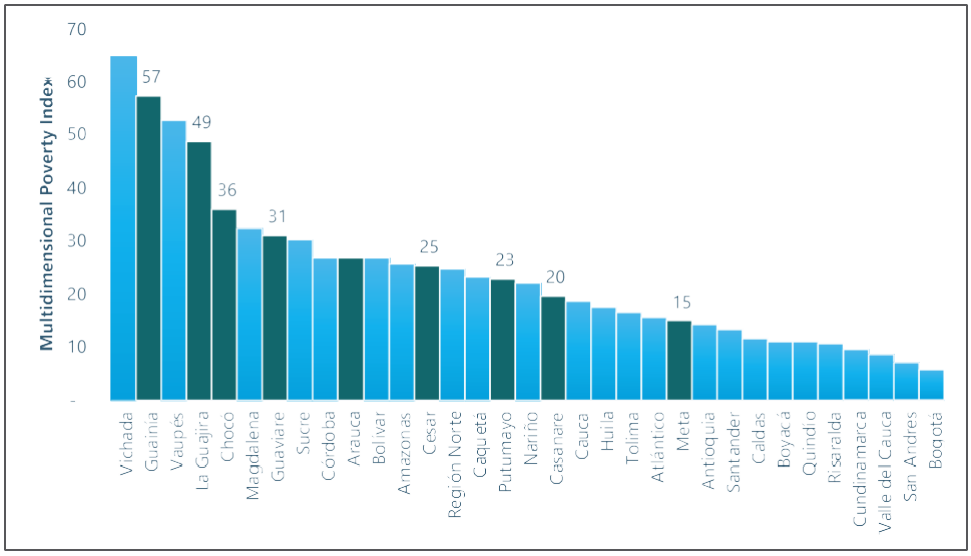



Source: DANE. Own work.

The mining sector is highly capital-intensive. While the direct job loss could be reduced, the resulting decreased economic activity can be absorbed by other sectors, particularly in mining-dependent territories. According to the Rasmussen-Hirschman index of economic linkages, the mining sector in Colombia is forward-oriented (DANE, 2020). This implies that it is crucial in contributing resources to the economy and serving as an input to other industries. Consequently, municipalities with poorly industrialised economies, with scarcely linked sectors and oriented to the final demand, will also be highly impacted, creating a domino effect. In particular, municipalities like Barrancas and Albania (Guajira), Becerril and La Jagua de Ibirico (Cesar), and Puerto Gaitan, Acacias and Guamal (Meta) all have over 85% of their value-added coming from mining activities.

The transferability of skills from mining to other emerging sectors, such as renewable energy, is uncertain. Workers with mining-related training usually have very specific skills which hinder their ability to find employment in other sectors (Saget et al., 2020). There is little certainty on whether new renewable energy projects will coincide with mining-dependent regions. Even if individuals can accommodate their skills, they would still have to migrate to other areas, impacting their quality of life. This is aggravated by the fact that the areas that will suffer job loss are also the most vulnerable, as shown in Figure 3-8.

**Figure 3-8. Multidimensional Poverty in Mining-Dependent Departments**



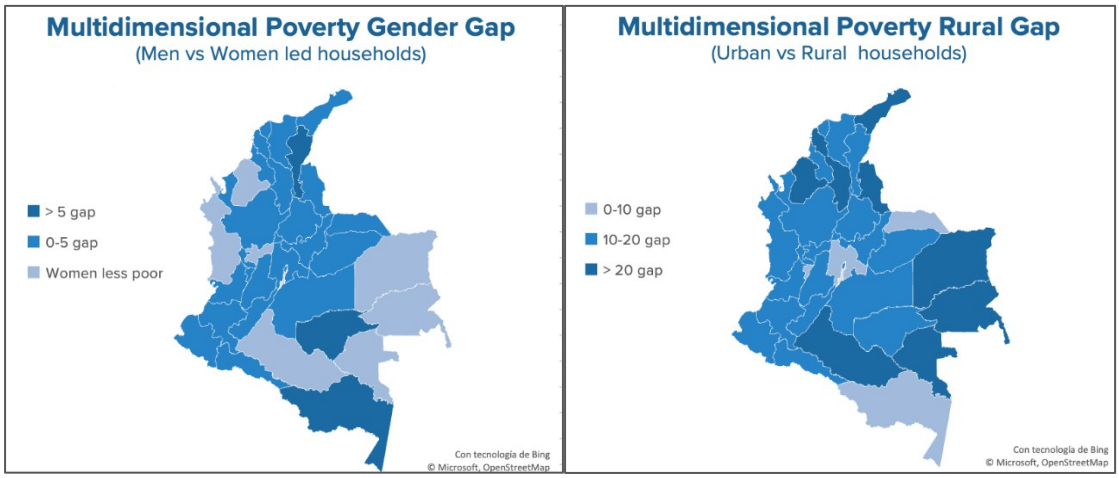

Source: DANE. Own work

## 3.4 Multidimensional Poverty Gaps: Gender, Rural and Ethnic

**The high poverty gaps in women, ethnic, and rural populations challenge the energy transition to account for existing disparities.**

Access to the services and economic well-being that allow individuals to escape multidimensional poverty is not evenly distributed across the territory. As shown in Figure 3-9, the intersectionality of poverty and other demographic dimensions shows gaps within and across regions.

**Figure 3-9. Gender and Rural Gaps**

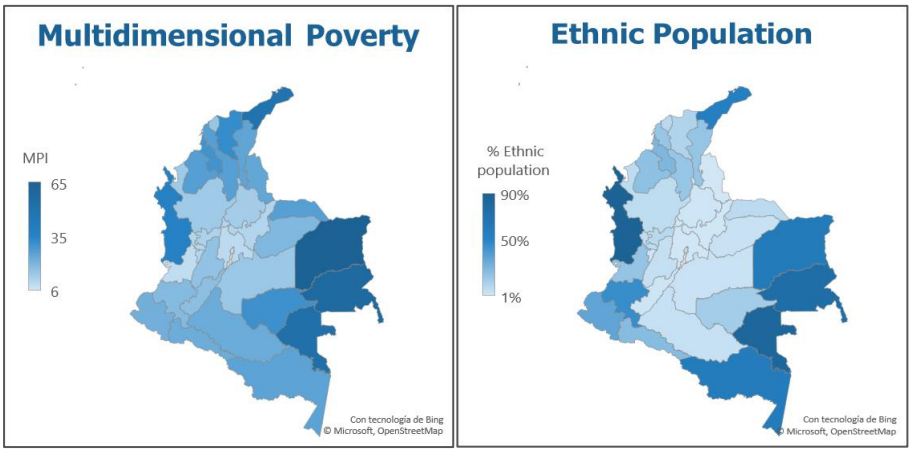



Source: DANE. Own work

In most Colombian departments, women-led households are poorer than households led by men with only seven departments, having women-led households that are, on average, less poor than men-led households. Four of these seven departments are among the poorest departments in Colombia. The mining sector employs 88% men and 12% women, so the transition offers a possibility for increased labour market access for women.

The disparity between rural and urban areas is a matter of concern in the transition. The multidimensional poverty rural gaps are much more significant than the gender gaps, with eight departments having gaps over 20 points. These gaps could be widened if the reduced role of mining is replaced by activities that agglomerate in urban centres. The rural poverty gap intersects with the vulnerable situation of ethnic communities in Colombia. Colombia's demographic and ethnic majority is of mixed races ("Mestizos and Mulatos"), different indigenous, raizal and afro communities find themselves still severely disadvantaged. This is shown as the overlap of the poverty and ethnic population maps shown in Figure 3-10. The best way ethnic populations can be a part of the transition without disrupting firmly held and valuable beliefs is still a matter of further and detailed study.

**Figure 3-10. Ethnic Poverty Gaps**

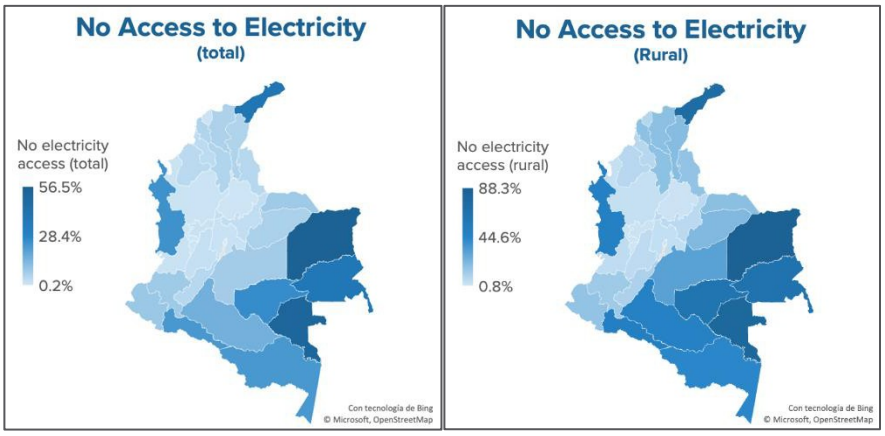



Source: DANE. Own work

**Access to electricity and clean fuels is particularly low in rural areas.**

Access to energy underpins equality of opportunities, especially as the world becomes increasingly digital. Thus, energy security and fairness should be a pillar of the transition. However, Colombia will find many challenges in this regard. The population without access to electricity ranges from 0.2% in Bogotá DC, to 56.5% in Vichada, and the gaps in rural areas are even wider (see Figure 3-11). Full electrification implies a considerable increase in electricity demand, stressing the electricity matrix, potentially affecting prices and pushing Colombia towards energy imports.

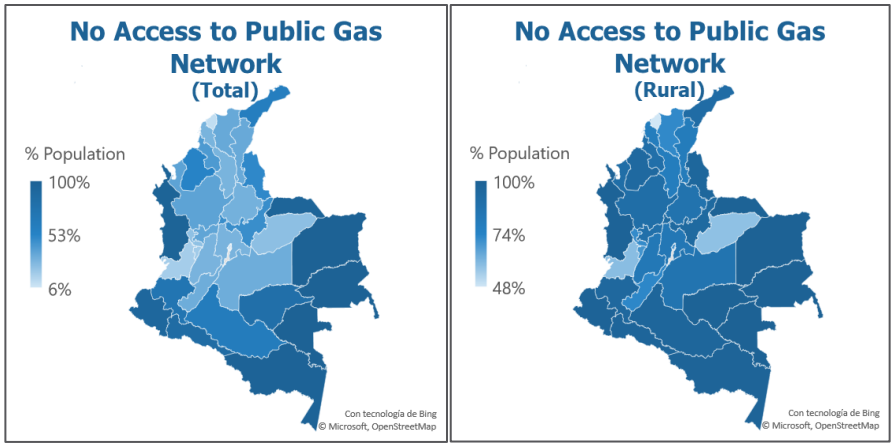
**Figure 3-11. Access to Electricity**




Source: DANE. Own work.

Access to public gas networks represents a challenge for the energy transition. As shown in Figure 3-12, the average lack of access to public gas networks in rural areas is 86%. As an alternative, people rely on more polluting and health-damaging fuels such as coal and wood for cooking and heating. Much is needed in terms of infrastructure investment to allow people access to gas. Pulling people out of energy poverty will not be plausible without addressing this gap.

**Figure 3-12. Access to Public Gas Network**




Source: DANE. Own work.

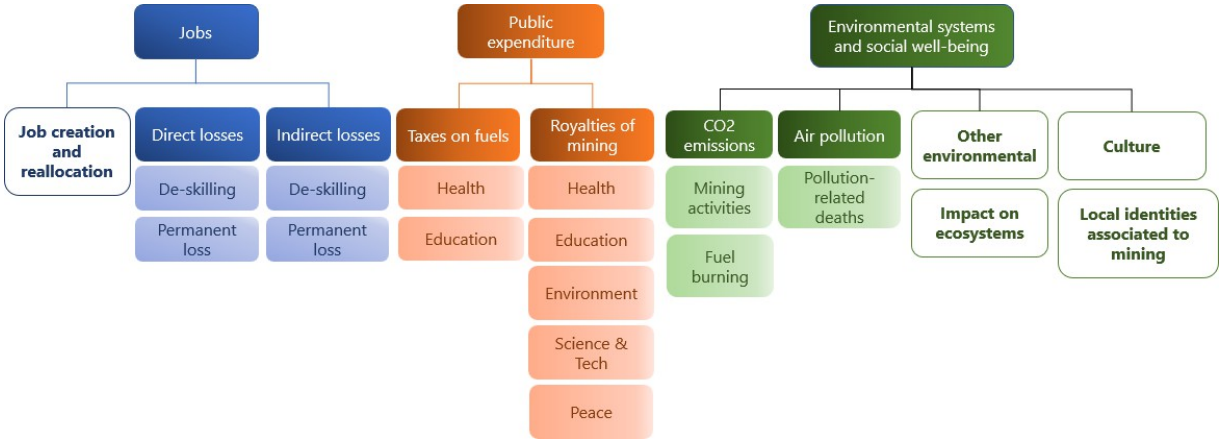
# 4 Cost Benefit Analysis Methodology

A cost-benefit analysis (CBA) is the main analytical framework for evaluating public expenditure decisions. It does so by systematically contrasting the full spectrum of costs and benefits. Traditionally, CBAs have tended to emphasise a decision's economic and financial consequences. However, the Colombian energy transition requires a people-centred analysis, focusing on the economic, social, and environmental costs and benefits of the transition, and underscoring the characteristics of the affected communities. On that note, the CBA is centred on two central policies of the Colombian energy transition: reducing oil and gas production and closing coal mines, along 25 years running from 2023 to 2048.

The considered policies were selected owing to their saliency, feasibility and availability of information. Reducing oil, gas and coal production is salient in public discourse, as these sectors are straightforwardly associated with emissions. It is also a current point of political contention because of the trade-offs it imposes. In addition, the industry’s future is highly dependent on the policies in place. For instance, regulation and awarding exploration and extraction contracts are effective tools to control the production in extractive industries, especially if SOEs such as Ecopetrol are involved. Finally, due to its saliency and the many organised stakeholders involved, a high level of information is available, allowing the characterisation and modelling of the phase-out consequences.

The considered policies have the potential to highly disrupt the life of people affected by them on multiple levels. These were categorised as shown in Figure 4-1.

**Figure 4-1. Variables Analysed**



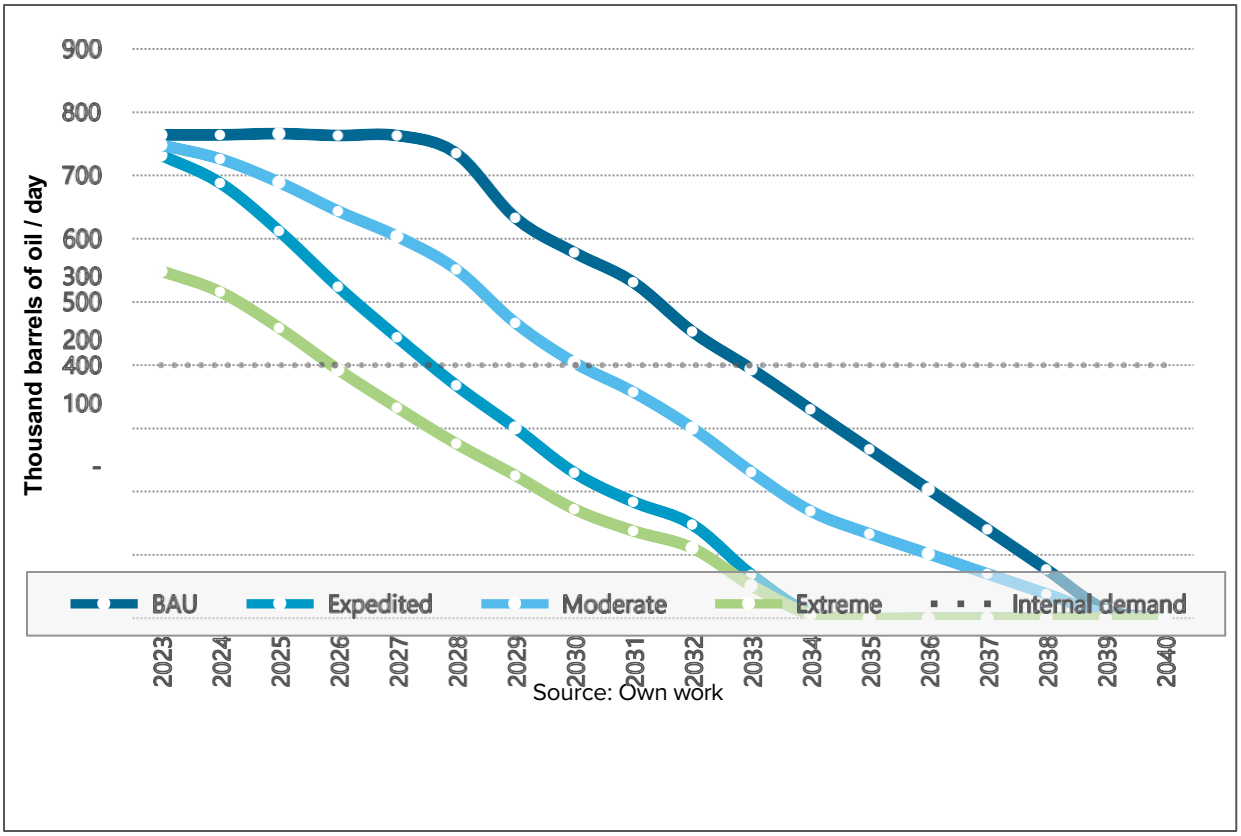

Source: Own work. Note: variables highlighted in colour were quantified, while blank variables are discussed qualitatively.

## 4.1 Modelled Scenarios

Four oil and gas scenarios are considered: “business as usual (BAU)”, “expedited”, “moderate”, and “extreme”. The first two scenarios (BAU and expedited) are taken from projections done by the Colombian Oil & Gas Association (ACP, 2022). Moderate and extreme are linear transformations from the BAU and expedited scenarios to reflect moderate and extreme cases.

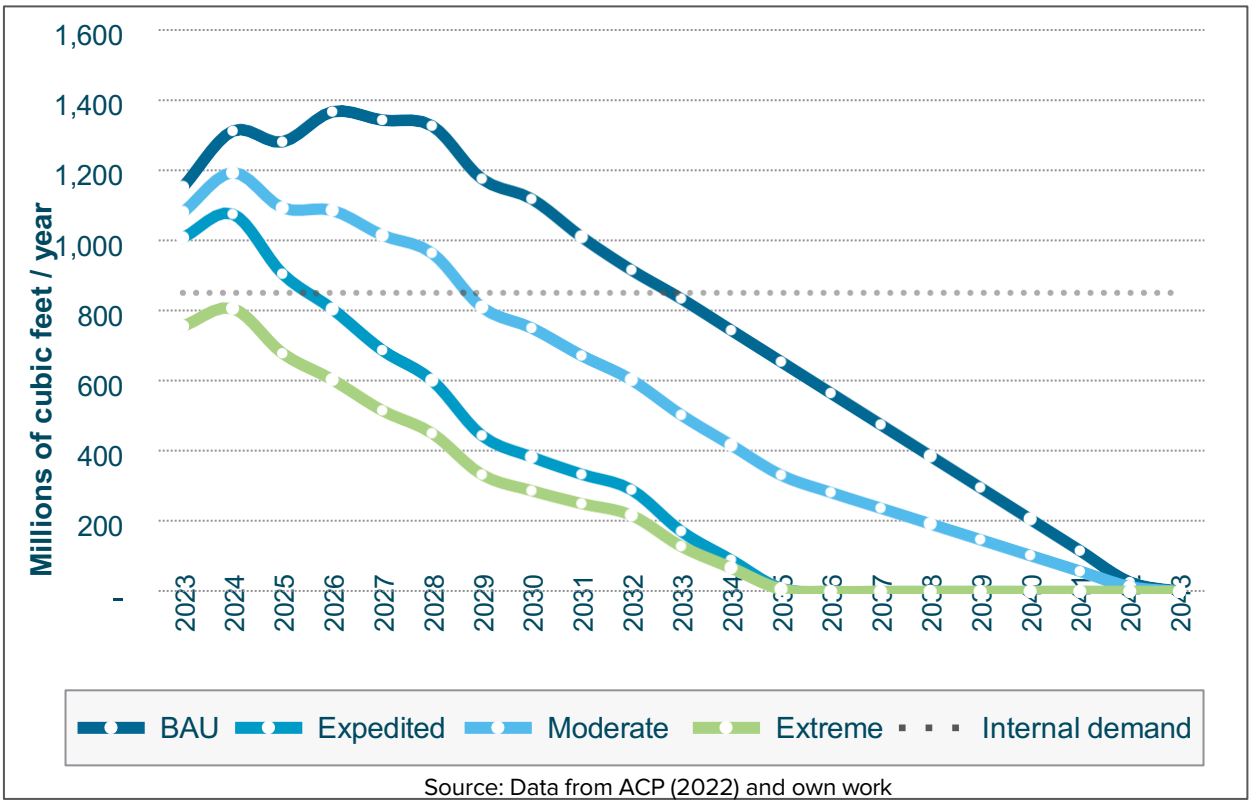
The BAU case, assumes that there are no changes to the existing policies. On the other hand, expedited entails a complete stop of exploration but with extraction occurring until reserves are depleted. Moderate assumes that there will be some reduction in the exploration, albeit not total. This aligns with political and climate commitments to reach net zero by 2050 and is equivalent to the average of the BAU and expedited scenarios. Lastly, the extreme scenario adds an additional 25% reduction in production beyond the depletion of reserves from the expedited scenario. Based on current internal demand, Colombia would stop being self-sufficient for oil and gas.

**Figure 4-2. Oil Production by Scenario**




Source: Own work

**Figure 4-3. Gas Production by Scenario**

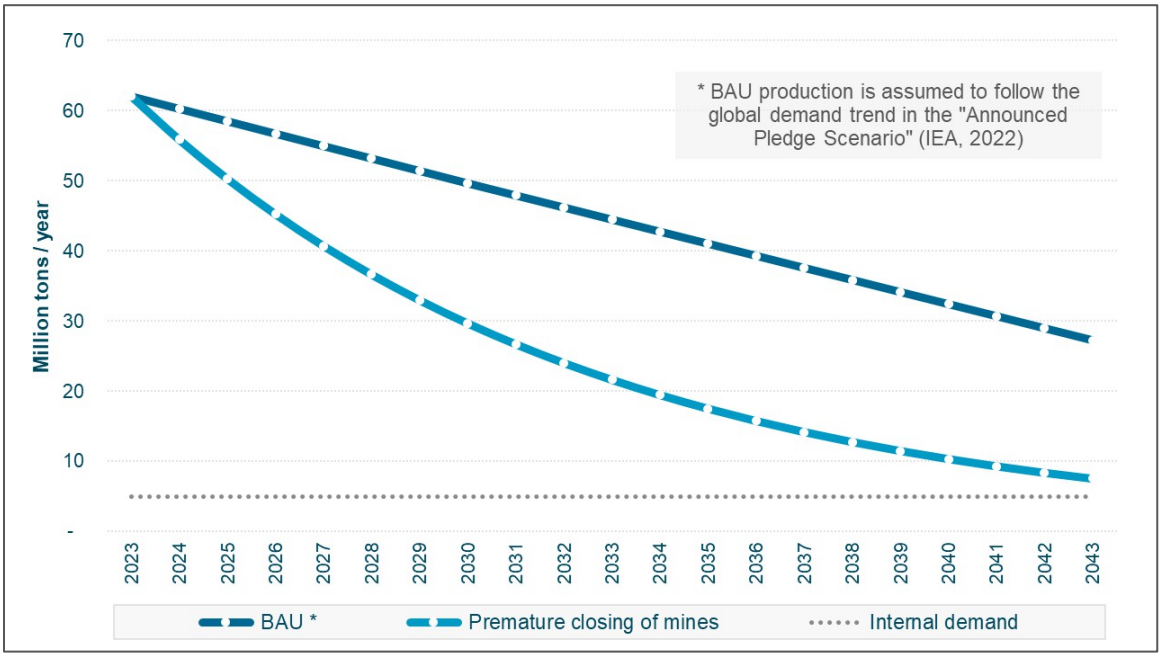



Source: Data from ACP (2022) and own work

Similarly, two coal scenarios are considered: "BAU" and "premature closing of mines". The BAU scenario assumes that there are no voluntary changes to existing policies, energy production or transition. Instead, it assumes global demand for coal decreases in a path that adheres to the announced pledges by countries[6]. The premature closing of mines considers an accelerated mine closure with negligible production by 2040.

[6] See: Announced Pledges Scenario, by the IEA (2022)

**Figure 4-4. Coal Production by Scenario**




Source: Own work

## 4.2 Valuation of CBA Components

### 4.2.1 Government Revenue

The most methodologically simple estimation is that of the revenues. For oil and gas, ACP (2022) estimates both the production scenarios and the equivalent revenues from royalties, taxes and capital revenues from SOEs. The revenues for the oil and gas scenarios are adjusted by the same linear transformation. For coal, a base for tax revenue and royalties is established for the current coal incomes, which are subject to a price that is more than double the long-term expected price. This base is then linearly transformed to fit the trends for each scenario. The reduced revenues are then translated into reduced expenditure, which follows the regulatory allocations of royalties and the average allocation of education and health revenues for the general budget. Reduced taxes and capital revenues across departments are distributed by population. Regarding royalties, the regulatory allocation from 2021-22 is considered.

### 4.2.2 Job Loss

Direct overall job loss is estimated by assuming a static labour ratio and applying it to the production scenarios. “Permanent” job loss is the number of people who lose their job and don’t find a new one right away. This is estimated using each department’s unemployment rate measured by DANE as a probability of not finding a job. “De-skill” loss is also estimated, accounting for people who find a job that results in a downgrade from their original position. This is calculated considering the subemployment rate and an assumed reduction of income of 25%. The estimated jobs lost are monetized by multiplying the permanent and de-skilled by the income they stop receiving, which is assumed to be equal to the department’s per capita income. Indirect job loss, on the other hand, is the product of the direct permanent job loss and a mining linkage multiplier (UPME, 2017). That is, the level of dependence of other industries on coal or oil and mining production.

### 4.2.3 Climate Impact

Carbon emissions associated with mining have two main origins: mining activities and fuel burning. To distinguish between them, they are referred to in the model as direct and indirect emissions, respectively. Emissions for each type of fuel are quantified using an emission factor (details in Table 8-3 in Appendix A) multiplied by the production trends of each scenario. The avoided damage is quantified by relativising each department’s Climate Risk index with Colombia’s total risk (Minambiente, 2017). Regardless of their production status, all departments benefit from the emission reduction. The damages associated with emitting carbon are monetised through a direct approach, using a social cost of carbon of 25 USD per CO2 ton. This value corresponds to the mean value found in the literature relevant to Latin America (CEPAL, 2019). A sensitivity analysis is also run to account for the vast range of social cost of carbon value found in the literature (refer to Section 4.3)

Note that this methodology assumes a change in production translates into a change in fuel burning. Moreover, it assumes that such reductions result in an immediate benefit

for the population and that the level of vulnerability and adaptative capacities remain constant in time. These assumptions and their implications are further challenged and discussed in Section 4.3.

### 4.2.4 Health Effects

Equation 4-1 summarises the methodology used to quantify the reduction in excess mortality associated with better air quality due to the cessation of mining activities. Namely, the change in health risk associated with a reduction in pollution each year is scaled by the population nearby the mine site and the probability of death. Pollution is proxied by fine particulate matter emissions ($MP_{2.5}$), a relevant pollutant of mining activities (EEA, 2019; Gonzalez et al., 2022). The link between pollution and saved lives is made through the health effect estimate, which accounts for the percentage change in mortality risk due to a unitary change in air pollution. The epidemiological research in Colombia is still incipient (UN, 2019); therefore, an appropriate country-specific health effect estimate isn't available. Instead, the value used results from a thorough meta-analysis of international studies by Pope et al. (2020). It comprises multiple population characteristics, pollution sources, and all non-accidental death causes associated with fine particulate matter ($MP_{2.5}$). The economic value of the saved lives is calculated using the Colombian value of statistical life (VSL). This value is estimated using a benefit-transfer function to convert the VSL of OECD countries into a value relevant to Colombia, following the approach shown in (World Bank Group, 2021b). A more detailed explanation of the methodology and the values used can be found in Appendix B.

**Equation 4-1 Mortality Valuation Schema**

Value of reduced mortality

= Air quality change × Health effect estimate × Exposed population × Mortality baseline incidence × Statistical value of life

Source: Adapted from (US-EPA, 2022a)

The calculation of the health effect assumes that the gradual seize of mining activities results in an immediate decrease in air pollutants around the mine site. It also assumes that all affected population is exposed to the same pollutant levels. Moreover,

it assumes average toxicity of the particulate matter, not specific to mining activities. These assumptions are further discussed and challenged in Section 4.3.

## 4.3 Parameter Sensitivity

To test the inherent variability associated with the main extrinsic parameters of the model, a sensitivity analysis of the discount rate and cost of carbon is performed.

### 4.3.1 Discount Rate

The discount rate sets the relative value of the costs and benefits assumed present versus the future. Thus, a high discount rate assumes a high valuation of immediate benefits versus future benefits. In this analysis, a higher discount rate value results in a higher magnitude of the overall net present value: a more positive number for benefitted departments and a more negative number for losers. The National Planning Department (DNP) sets out three different discount rates for social investment projects in Colombia, shown in Table 4-1. The results are tested under the three values.

**Table 4-1 Discount Rate Values**

| Evaluation horizon (years) | Discount rate |
|---|---|
| **0 – 5** | 9.5% |
| **6 – 25** | 6.4% |
| **26+** | 3.5% |

Source: National Planning Department

### 4.3.2 Cost of Carbon

The vast range of social cost of carbon found in the literature is accounted for through a sensitivity analysis applying the values 6 and 100 USD per $CO_2$ ton (CEPAL, 2019), in addition to the value of 25 USD per $CO_2$ ton,

Following a conservative assumption, the median options of each parameter were selected. Therefore, the results analysed in Section 4.5 consider the project evaluation of 6 – 25 years at a 6.4% discount rate and a cost of carbon of 25 USD. A discussion about how these parameters affect the results is included when relevant.

### 4.3.3 Scenarios

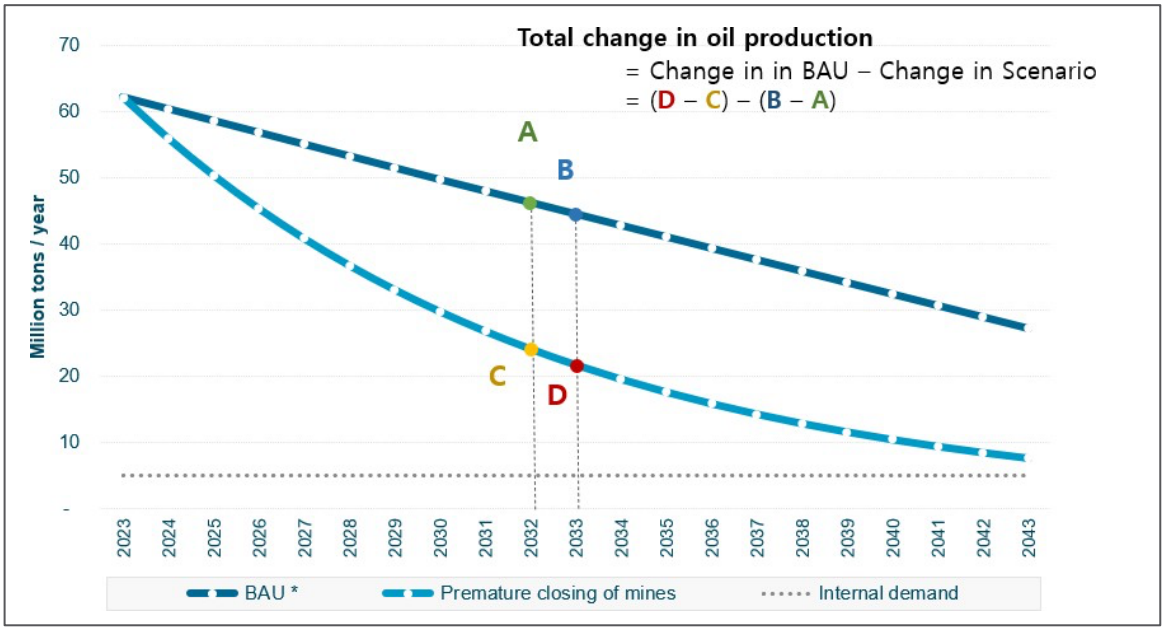
The main core of the analysis was conducted assuming Colombia would pursue a moderate pace. This moderate scenario results in the combination of the oil and gas moderate scenario and the closing of coal mines scenario. This implies that the distribution trade-offs are not as extreme as in the alternative scenarios.

The impacts of considering the additional scenarios presented in Section 4.1. are displayed in the results when relevant. The detailed individual results for the other scenarios are in the appendix.

## 4.4 Results Methodology and Interpretation

The model results assess the effect of choosing one scenario and contrasting it with the BAU cases of coal, oil and gas. The effects are calculated as the difference between the trend in the analysed scenario and in the BAU scenario. Figure 4-5 shows an example of this methodology using the coal scenarios.

**Figure 4-5. General Methodology for Calculation of Results**




Source: Own work

It is important to note that the results should not be narrowly interpreted in a binary way**.** That is, whether the costs are higher or lower than the benefits. Instead, identifying

costs and their relative size to the benefits signal to policymakers that these are relevant effects to be addressed on the road to a just energy transition. Therefore, the estimated outcomes of the model allow for identifying relative winners and losers and to gauge the magnitude of the economic, environmental, and social trade-offs for these policies aiming to transition Colombia away from fossil fuels.

## 4.5 Limitations and Further Research

In addition to the data restrictions discussed in Section 4.2, the CBA is limited in that it doesn't account for other policies that could harness synergies with the mining transition. These include policies such as the investment in hydrogen and other renewable technologies, the expansion of localised renewable energy production, the establishment of carbon capture markets, addressing deforestation, and addressing the electrification of industrial processes and transportation. In general, a lack feasibility regarding government action and an uncertainty regarding trade-offs and impacts discussed by (Cardenas & Orozco, 2022a), prevented these policies from being modelled in the CBA.

Although left outside of the model, their implications are further discussed across the analysis, albeit qualitatively.

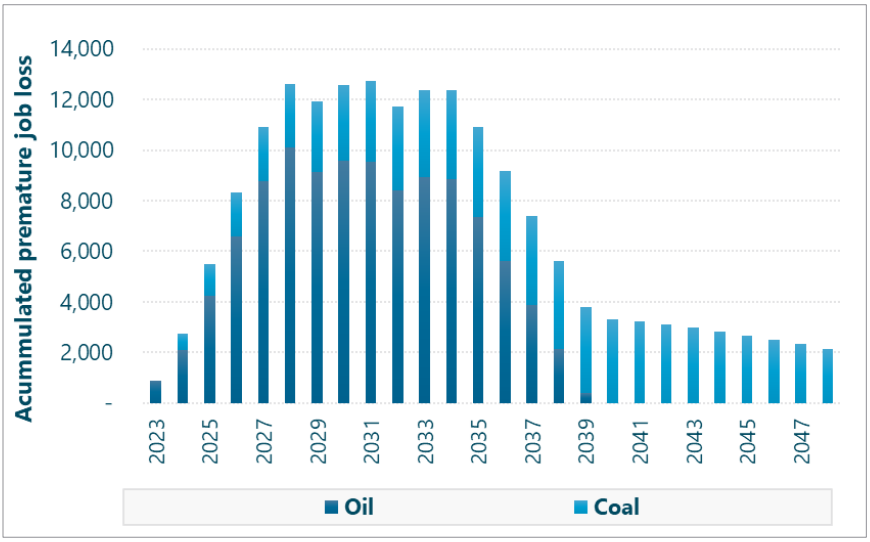
# 5 Analysis and Discussion of Findings

## 5.1 Jobs

**A moderate transition can result in 12,000 prematurely displaced workers that need to be absorbed by the economy within 5 years.**

Regardless of the transition pace, the fossil fuel production sector will experience job loss of roughly 100,000 workers due to the depletion of reserves and the global shift away from fossil fuels[7]. The question then becomes not how many jobs will be lost, but where and when.

**Figure 5-1. Total Accumulated Premature Job Loss**




Source: Own work. Note: the figure shows the premature job loss in the moderate scenario compared to BAU. Bars grow taller as more jobs are lost in the moderate scenario than what it would've been lost under BAU. Bars grow smaller when the jobs lost under BAU are larger than in the moderate scenario.

Figure 5-1 shows that, under a moderate transition pace, the increase in jobs lost prematurely is significant. In five years, the total premature job loss amounts to over 12,000. This number increases to around 19,000 if an expedited oil and gas scenario is considered (results not shown). As the pace of transition for coal is slower than for the oil and gas scenarios, the magnitude of premature jobs lost in the oil and gas industry

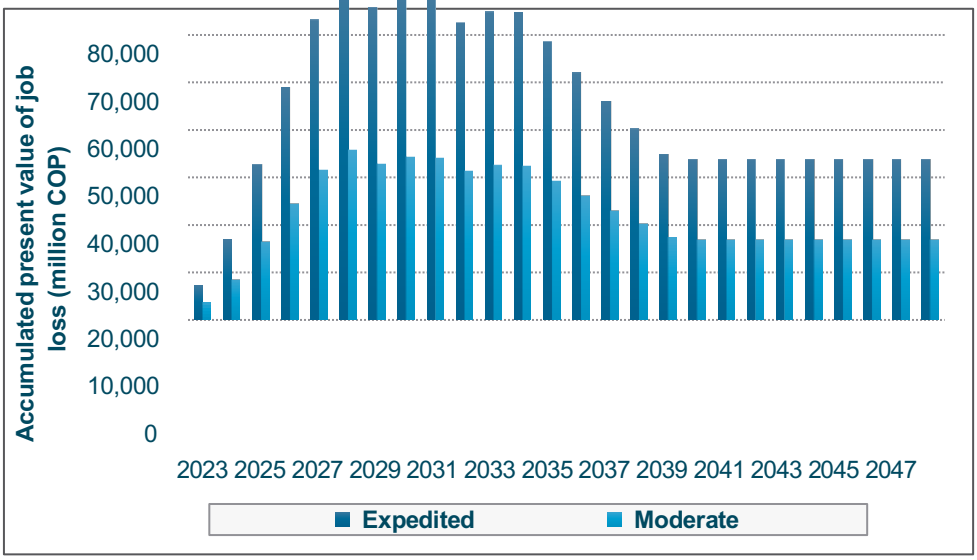
[7] Section 4.1 explain these dynamic in detail.

is much larger. Note that under a moderate pace, jobs in oil and gas will be depleted by 2040, while coal is never entirely depleted. In contrast, an expedited oil and gas scenario assumes jobs will be depleted by 2035[8].

**Most of the premature job loss is bear by two departments: Meta and Casanare.**

Nearly 95% of the premature job losses are concentrated in Meta and Casanare. Under a moderate transition, Meta will lose approximately 10,000 jobs prematurely in the next five years. Whereas Casanare will prematurely lose around 1,700 jobs. This will have a tremendous impact on the livelihoods of individuals who are employed in this sector.

**Box 5-1. Job Loss in Meta**




Meta will be disproportionately impacted by job loss during the energy transition. Their heavy reliance on oil production could see a premature reduction in jobs. Jobs are generally concentrated in municipalities, increasing the cumulative costs of job loss.

[8] For further explanation on the used scenarios please refer to Sections 4.1 and 4.3.3.

**Premature job loss will be concentrated in men, who are often the sole family income provider.**

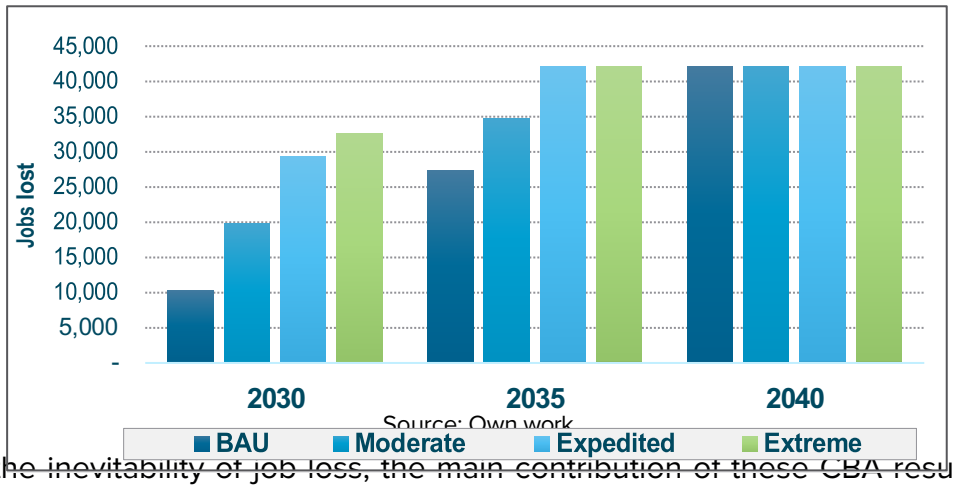
The loss of jobs will be highly concentrated among men, as they make up more than 85% of employees in mining, according to GEIH data. This problem becomes particularly challenging when considering that, in semi/rural mining towns, men are disproportionately the sole family income provider. Thus, the income loss of these men would affect the whole family's output, including the children. Furthermore, if skills are not transferable, and there are no re-skilling programmes, permanent job loss could increase significantly. These results are calculated assuming an average failure to be reemployed of 10%. However, if 50% of those who lose their jobs fail to get reemployed, the effects of job loss would be 3.4 to 6.8 times higher.

**Colombia's current job market would be unable to absorb the job loss.**

In 2020, the Colombian government launched the "Employment Mission" to assess the current problems in the labour market, deemed to be "multiple, profound and complex" causes, and has now suggested broad measures to improve employability. We argue that there needs to be a deeper level of planning for sectoral trends, such as that induced by the transition, as displayed here. As shown in Figure 5-2, the magnitude of job loss and the varying pace demands action to address the existence of other viable and relevant jobs that can be filled by the displaced workers. However, a World Bank report highlighted that "employment in Colombia is insufficiently diversified, relying almost exclusively on job creation in the service sectors" (World Bank, 2022, p. 15). Besides these jobs potentially not being within the affected departments, they might also be incompatible with the mining workers' skills and expectations. As it relates specifically to the workers, the report found that "the economy generates too few formal employment opportunities for those with fewer skills and those living in rural areas" (World Bank, 2022, p. 15). Thus, the lack of diversity within the labour market threatens the ability of displaced workers to find alternative work.

On the other hand, because O&G and Coal represent such a large share of overall output, one would expect spillover effects both in value chains and in other sectors, both in terms of output and jobs. That is not the case. As the input-output matrix in (DANE, 2020) notes, mining and extraction sector has very small backward linkages, meaning that the effect on value chains, and the resulting indirect job loss is going to be small, as our results confirmed. However, as a sector with such vast output, and relatively more forward linkages, those who stand to lose are the highly mining dependant municipalities listed in Section 3.3, which would see a massive drop in demand and available income.

**Figure 5-2. O&G Jobs Lost with Different Transition Paces**




Source: Own work

Given the inevitability of job loss, the main contribution of these CBA results is to allow policymakers to anticipate where and when jobs will be lost, subject to the chosen transition pace. This information is crucial to plan accordingly to generate the capacities to compensate those who stand to lose.

## 5.2 Fiscal Revenues, Royalties and Expenditures

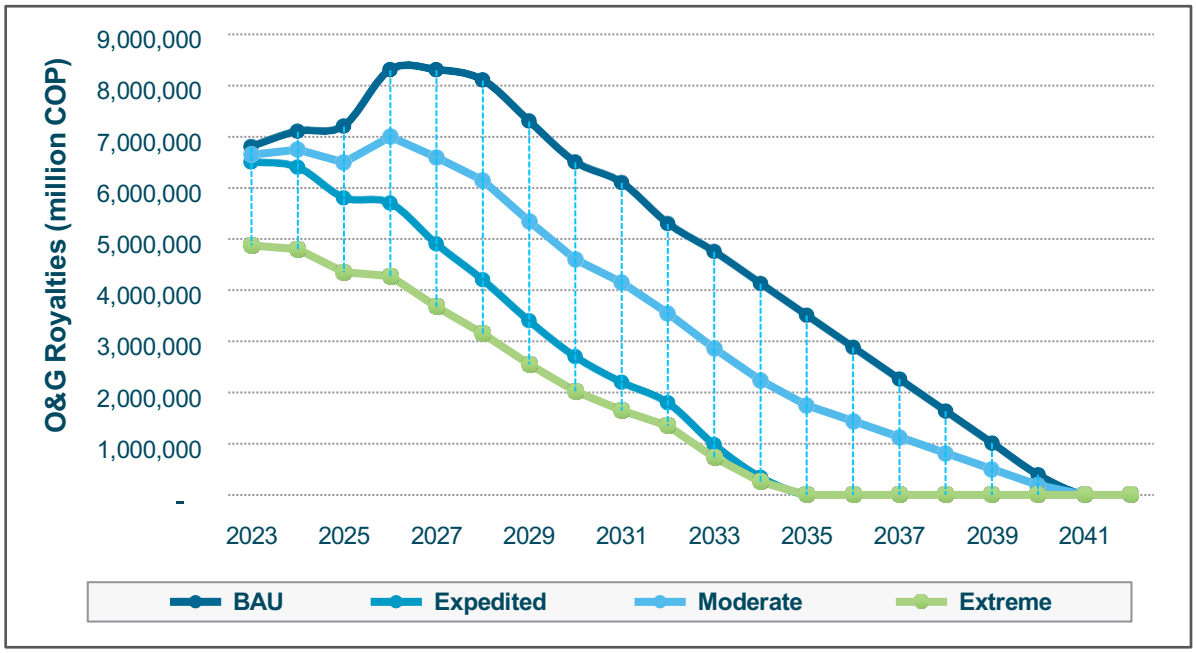
**Under a moderate scenario, revenue loss accounts for roughly 3% of GDP**

As discussed in Section 3.2, royalties from mining activities play a crucial fiscal role. The distribution pattern of royalties suggests they are mainly allocated towards the central and northern departments. However, from a per capita perspective, the

distribution is heavily skewed towards the southeast, with a strong overlap in the Orinoquia's mining-intensive departments of Casanare Meta and Arauca. In addition, the mining-intensive La Guajira department and the more vulnerable department of Chocó also collect much of the relative benefits. This distribution results from regulatory allocations and will simultaneously shape the map of those who stand to lose from the decrease in royalties.

Given that all scenarios of O&G production decrease in time, departments show a reduction in royalties received irrespective of the scenario. The difference, however, is the speed of the decline. As shown in Figure 5-3, an expedited or extreme transition away from oil and gas would see the royalties vanish by 2035, while a moderate phase- out would allow more time to reconfigure the fiscal income sources.

**Figure 5-3. Oil and Gas Royalties**

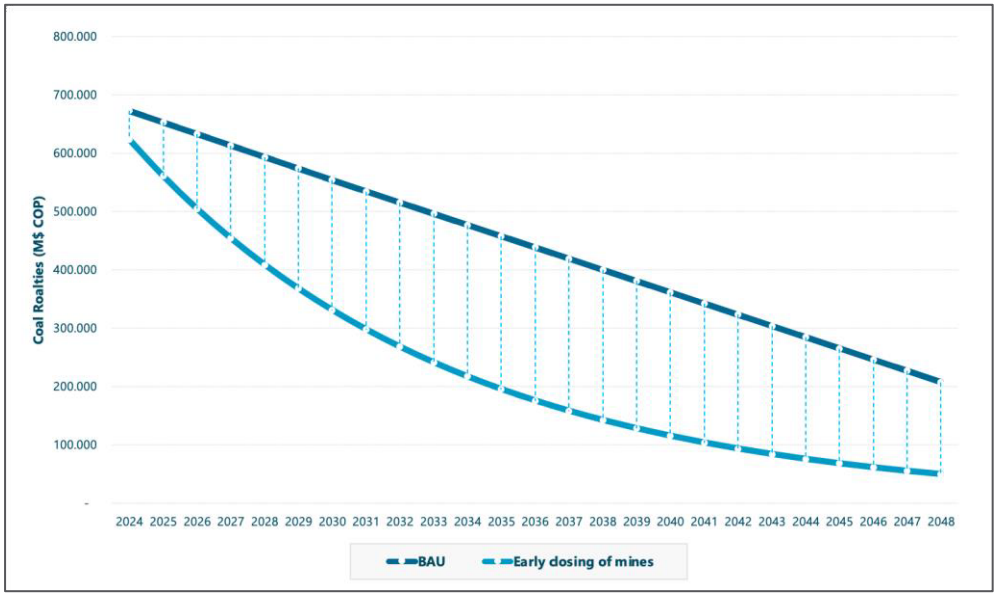



Source: Data from ACP (2022) and own work

Similarly, the loss of royalties of coal will decrease faster if the mines close earlier than expected in the business-as-usual scenario. Therefore, the question is whether to allow the global decline in demand to induce a reduction in Colombia's coal production (i.e., follow the BAU scenario) or to take anticipated action by closing the mines early.

The costs of the latter are depicted by the dotted space between the two scenario curves in Figure 5-4. The net present value of these losses is 24.210 million COP over the period, which increases when considering higher discount rates.

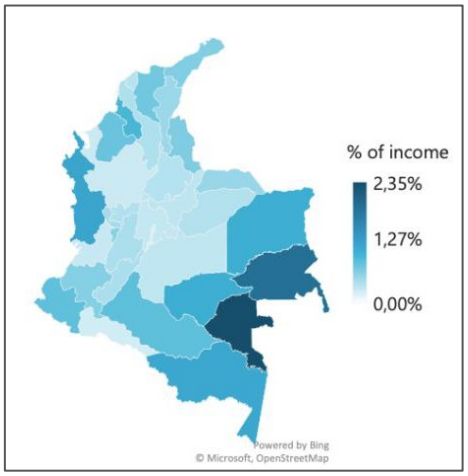
**Figure 5-4. Coal Royalties**




Source: Own work

The losses from O&G and coal taxes, and from the profits from Ecopetrol, will follow the same scenario trends as the ones displayed in Figure 5-3 and Figure 5-4, but close to four times larger (see Figure 5-7). Taxes and capital income amount to 26.2 billion COP and royalties to 8.7 billion COP. In total, this accounts for roughly 3% of GDP. The most prominent loss comes from O&G taxes and capital income.

**Figure 5-5. Premature Loss of Total Revenues as a Share of GDP**



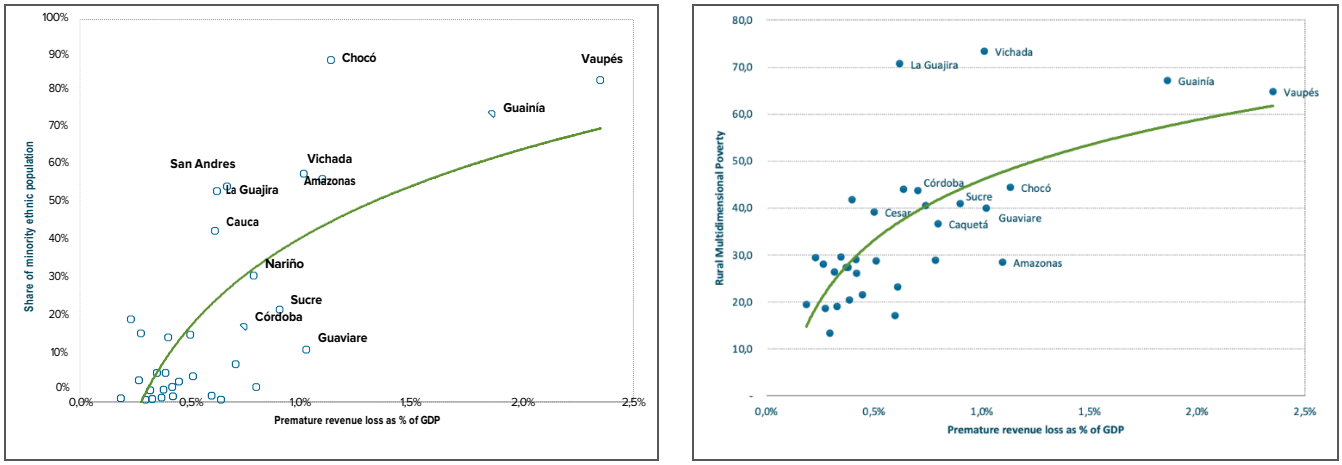

Source: DANE and own work

**Revenue loss disproportionately affects minorities and vulnerable population**

The loss in revenue from royalties will vary across departments, following the current framework for subnational transfers distribution and the regulatory subnational allocations for royalties. Figure 5-5 maps this premature loss of revenue[9]. Naturally, because transfers to subnational governments are increasing relative to GDP as the department's income level decreases, a large loss of revenue will proportionately impact low-income departments more. Due to the correlation between income and vulnerable population, the disproportionate loss by the lowest income departments will overlap with other factors such as minority ethnic identification and multidimensional rural poverty (Figure 5-6).

[9] Premature loss of revenue is the NPV of the sum of the difference in difference effect on the anticipated revenue loss due to a faster transition.

**Figure 5-6. Relative Revenue Lost, Ethnicity and Rural Poverty**



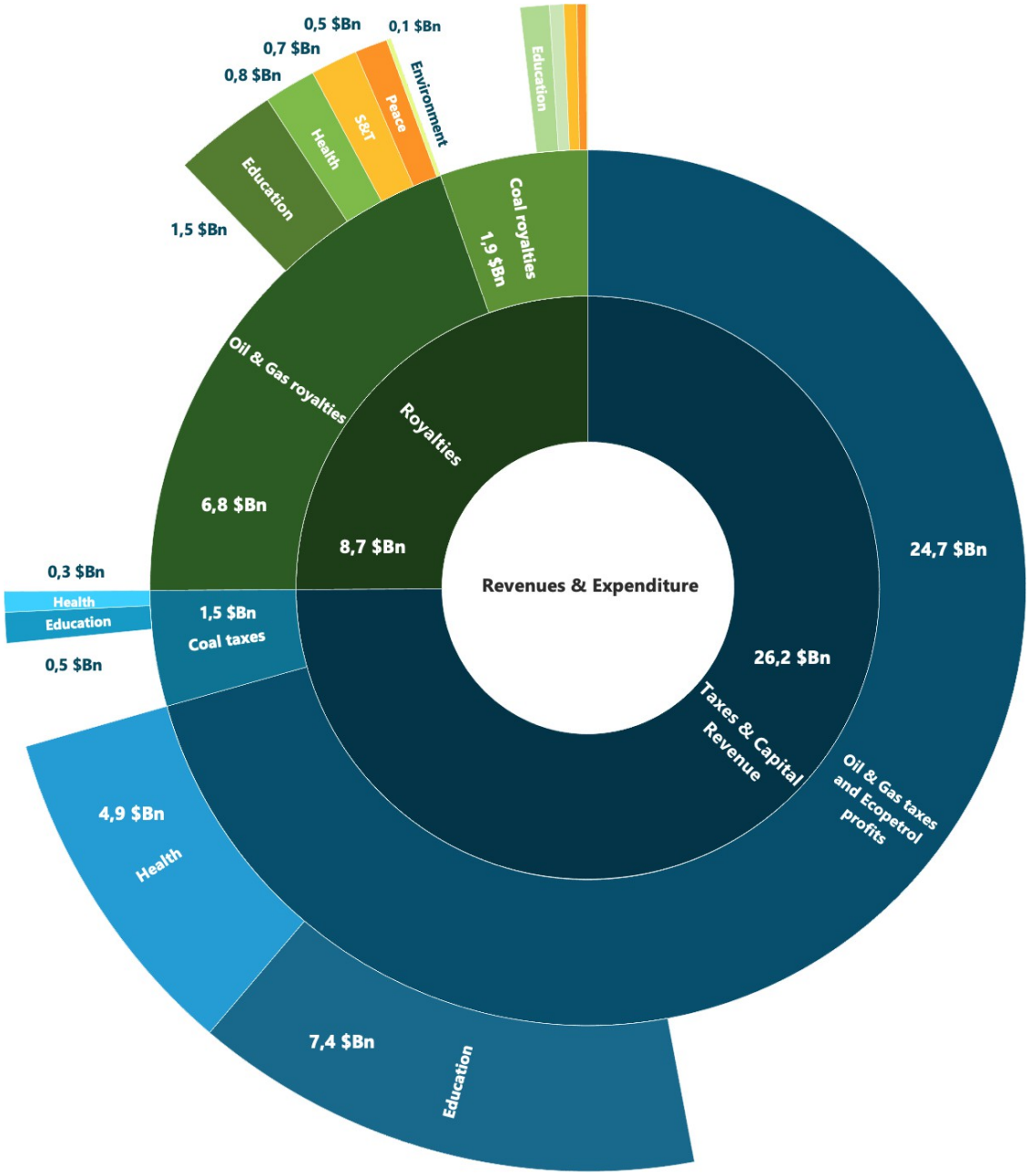

Source: DANE and own work

**Regardless of the transition pace, funding for human development will vanish.**

Figure 5-7 shows the revenues Colombia stands to lose from the fossil fuel production phase-out in the inner rings. The outer rings show the corresponding expenditure lines and the magnitude by which they would need to be cut following the revenue loss, according to the current allocation. The associated reduced expenditure of 9.7 billion COP (~0,85% of GDP) on education and 6.1 billion COP (~0,53% of GDP) on health pose a major challenge in Colombia's human development path.

Notably, the regulatory allocations for sustainability projects are comparatively small. The current royalties framework is designed to be spent on human development with little regard for the role that the mining proceeds in funding their future renewable alternatives. No matter the pace of the transition, these revenues will vanish, leaving education and health unfunded, and renewable infrastructure underdeveloped.

**Figure 5-7. Revenues and Estimated Corresponding Expenditure Lines**



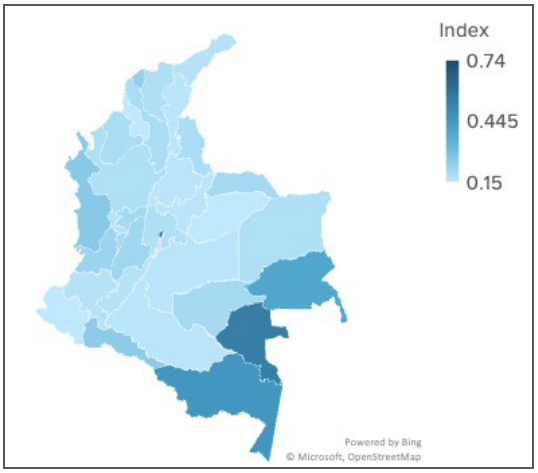

Source: Colombia MTFF 2022, National Accounts, Drummond, Sistema General de Regalías.

## 5.3 Climate Impact

**Lower carbon emissions benefit all Colombian departments, albeit diversely.**

Lower carbon emissions associated with the mining, production and burning of fossil fuels positively impact global climate change. Colombia, which is highly vulnerable to extreme weather events, would benefit from a slower global warming rate (World Bank Group, 2021a). Climate-related impacts are not homogenous across the population but depend on socioeconomic status, access to resources, and economic activity (World Bank Group, 2021a). Departments dependent on agriculture activities will be more affected than urban areas by continued droughts, varying temperatures, and biodiversity loss. These differences in hazards, vulnerabilities, and adaptative capacity are summarised in a Climate Risk Index developed by the Ministry of Environment of Colombia (see Figure 5-8). Thus, regardless of the origin of emissions, reducing carbon emissions will benefit all Colombian departments. A more significant benefit is expected for the most climate-vulnerable ones.

**Figure 5-8. Climate Risk Index**




Source: Own work. (Minambiente, 2017)

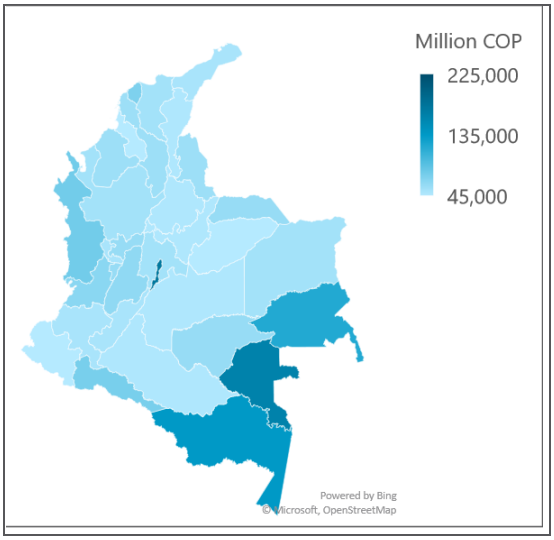
Note that, due to the focus on existing mining activity, these benefits don't consider the emissions associated with lower deforestation. Conservative estimates quantify this value to have been 2.5 $MtCO_2e$ during the period 2001-2018 due to the opening or expansion of coal mines in Colombia (González-González, Clerici, & Quesada, 2021). That is, around 1% of the yearly emissions accounted for the mine operation and fossil fuel. Moreover, forests play a relevant role in climate change adaptation. Consequently, departments in which fossil fuel extraction activities would take place in the future would benefit in addition to the current estimations.

**Lower carbon emissions mainly benefit the poorer and most vulnerable departments.**

Figure 5-9 shows the benefits associated with the change in emissions in Colombia. A rushed stop in the exploration and exploitation of oil, gas and coal results in a decrease in emissions for all departments, with benefits ranging from 45 to 225 billion COP under the "moderate" scenario.

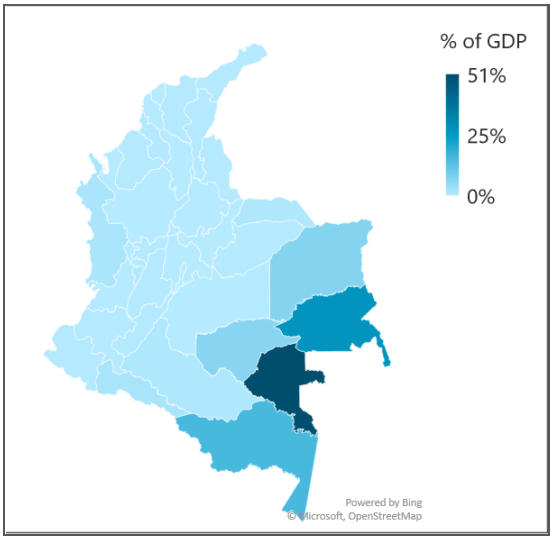
**Figure 5-9. Net Present Value of Climate Impact**

(a) as million COP




Source: Own work. Note: San Andrés and Providencia Department has the highest benefit, but it is not shown in the map

(b) as percentage of GDP




Source: Own work.

As stated in the methodology, the main absolute benefits are absorbed by the departments most vulnerable to climate change: San Andrés, Vaupés, Guainía, Amazonas, and Chocó. However, relative to GDP, the benefits mainly concentrate in the country's south-eastern region, dissipating the spread-like results of the absolute benefits.

In general, the benefitted departments are amongst the poorest in Colombia, as measured by the Multidimensional Poverty Index (see Figure 5-10). As shown in Figure 5-11, indigenous populations – which are particularly vulnerable to climate change risks (UN, 2021) –also tend to make up for large fractions of the most benefitted departments.

However, La Guajira, Vichada and Chocó arise as exceptions. Although these departments have high levels of poverty and low levels of climate change adaptation, they expect relatively few occurrences of high temperatures and droughts compared to departments (Minambiente, 2017). Consequently, lower carbon emissions would result in benefits that will be particularly relevant in the poorer and most vulnerable regions of Colombia

**Figure 5-10 Climate Impact vs MPI**

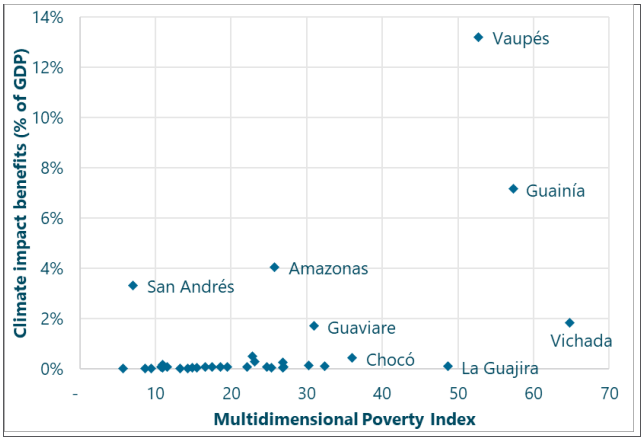
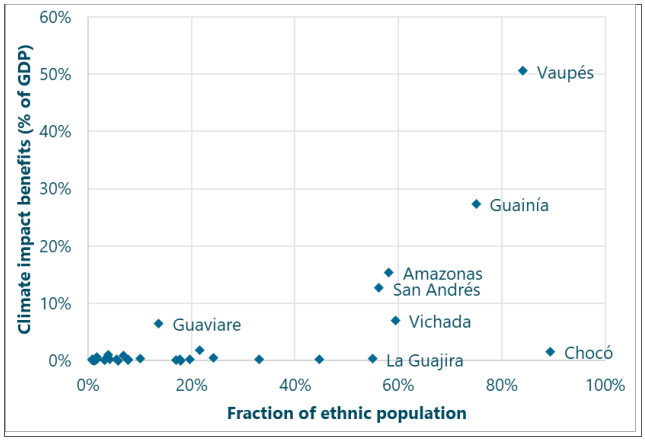


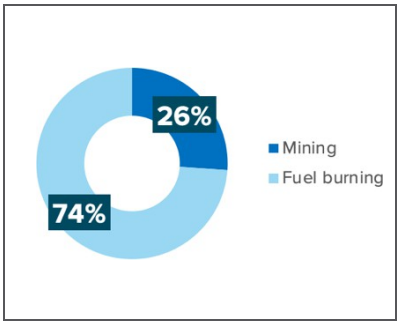

**Figure 5-11 Climate Impact vs Ethnic Fraction**




**But materialising much of the benefits depends on actions beyond Colombia's scope.**

As discussed in Section 4, carbon emissions from fuels have two main origins: mining and fuel burning. This categorisation allows distinguishing between the nature of the emissions and their expected evolution. While mining emissions are a direct consequence of Colombia's economic activities, fuel-burning emissions may or may not be affected by a reduction in Colombia's supply. Without Colombia's supply importing countries of fuel might choose to feed their demand from alternative markets. This is especially true for the oil and gas market, where Colombia is not a key exporter. Moreover, even

**Figure 5-12. Emission Distribution by Origin**

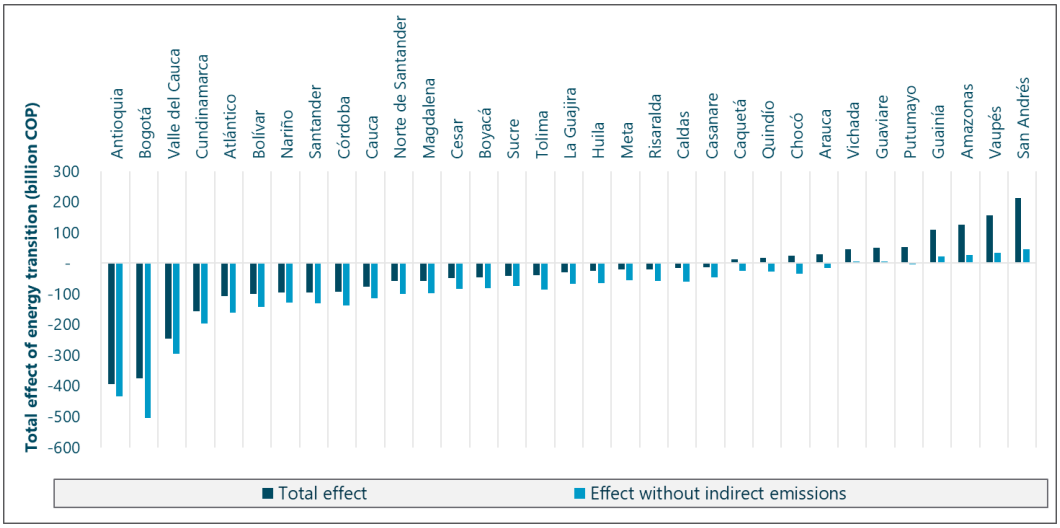



Source: Own work

without mining, Colombia is not expected to significantly decrease its fossil fuel consumption, given its relevance in energy access and security (Fedesarrollo, 2022).

Given the high associated emission factor, fuel-burning emissions account for 74% of the total carbon emissions, driving most climate impact benefits. As shown in Figure 5-13, the total costs associated with the energy transition increase significantly when indirect emissions are omitted. The change is particularly noticeable in the departments where the transition has net benefits. While this has no impact on the distributive effect discussed, it does imply that the climate-related benefits of mining will not be fully realised without efforts to reduce fossil fuel demand in Colombia and around the world.

**Figure 5-13. Change of Total Effect without Indirect Emissions**




Source: Own work

## 5.4 Health Impact

**Ceasing mining operations results in health benefits for some of the most vulnerable Colombian departments.**

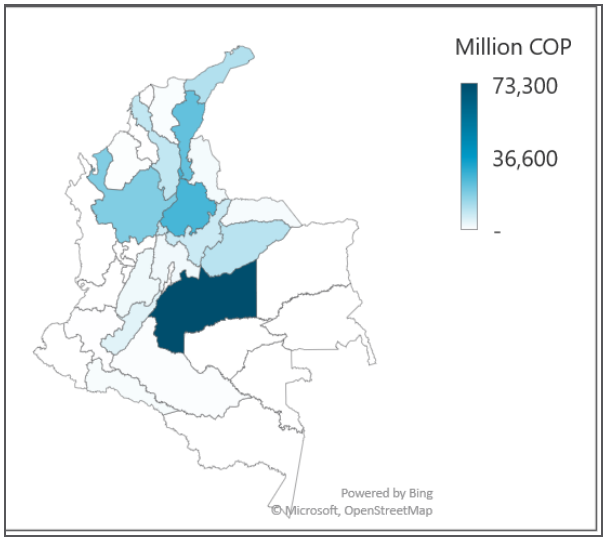
Fossil fuel production has been linked to increased air pollution levels, resulting in adverse health outcomes that can particularly harm those living nearby (EEA, 2019; González-Martínez et al., 2020; Gonzalez et al., 2022; Pope et al., 2020). Figure 5-14 shows the quantification of the health benefits – measured as avoided premature deaths – linked to a decrease in air pollution. While panel (a) shows the benefits measured as

million Colombian pesos, panel (b) relativizes the results to account for the departments' GDP.

Although Meta holds only 2% of the country's population, its health benefits over time are apparent under both metrics, stemming from its high dependence on oil production. Santander, Cesar and Antioquia also show significant benefits, albeit at a lower magnitude than Cesar (see panel (a) of Figure 5-14). The benefits of Santander and Cesar are a direct consequence of the high dependence on oil and coal production in each region, respectively. On the other hand, Antioquia holds just 2% of Colombia's fuel production but hosts a large part (13%) of Colombia's population. Thus, the amount of people at potential risk is much higher than in the other regions. However, the relevancy of Antioquia decreases once the benefits are relativised to account for GDP (see panel (b) of Figure 5-14). Instead, La Guajira is underscored as one of the most benefitted departments.

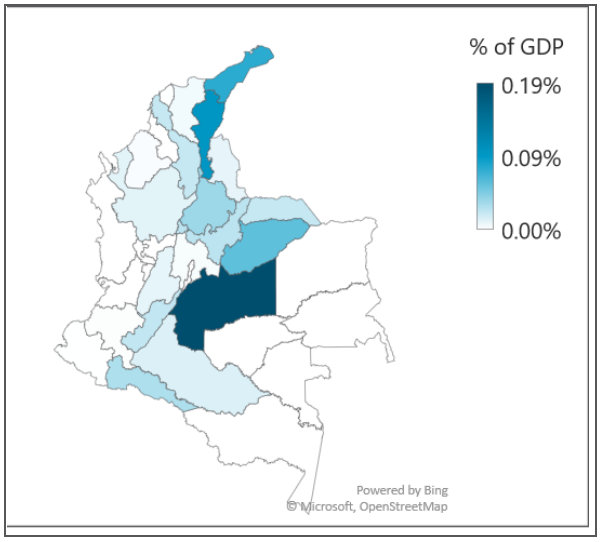
**Figure 5-14. Net Present Value of Health Benefits**

(a) as million COP




Source: Own work.

(b) as percentage of GDP



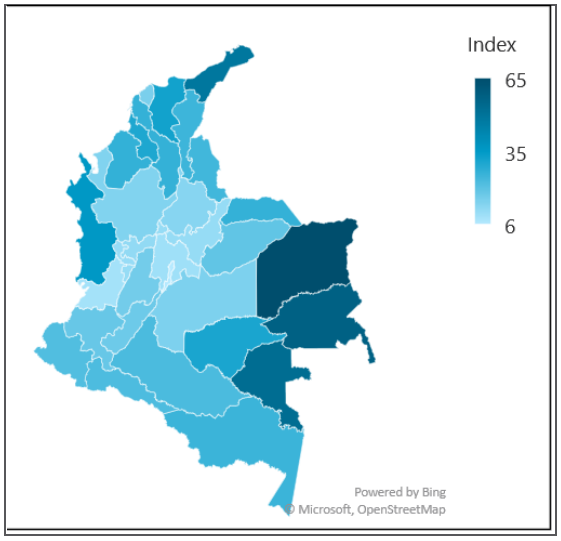

Source: Own work.

The benefits assumed by La Guajira highlight a relevant consequence of the transition. As previously discussed, La Guajira is one of the poorest departments in Colombia. Simultaneously, it's the most relevant coal producer in Colombia and hosts one of the world's largest – and, consequently, polluting – open-pit mines: El Cerrejon.

The region's poverty keeps the population more vulnerable to the effects of population than otherwise. In fact, fossil fuel production has been linked to respiratory issues in the Wayuu community (see Box 5-5). This result highlights positive consequences for a segment of the population that would be typically overlooked in favour of economic benefits. To examine this further, Figure 5-15 shows the Multidimensional Poverty Index for Colombia (panel (a)) and only for those departments that experience health effects (panel (b)). Although La Guajira is undeniably the most disadvantaged department being benefitted in this dimension, most of the other benefited departments also face high levels of poverty.

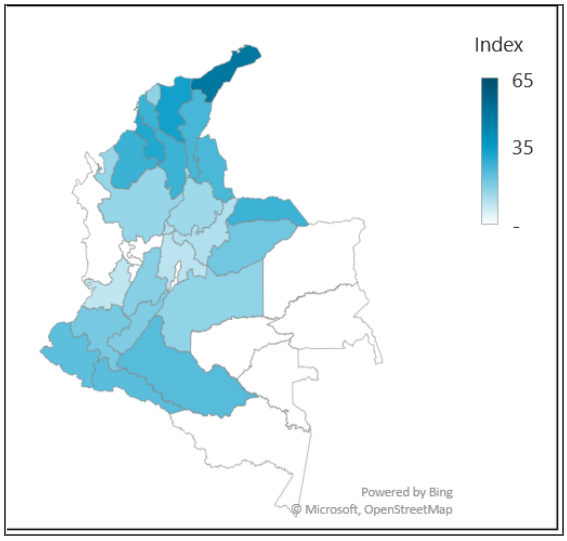
**Figure 5-15. Multidimensional Poverty Index**

(a) All Colombian departments




Source: Data from (DANE, 2021)

(b) Departments with health benefits




Source: Data from (DANE, 2021)

**The health effects are likely to be larger than estimated.**

The health effects monetised in the CBA focus on premature mortality associated with fine particulate matter. While the value per affected person is the highest when considering deaths – and therefore should account for most of the monetary impacts – , other health impacts cannot be overlooked.

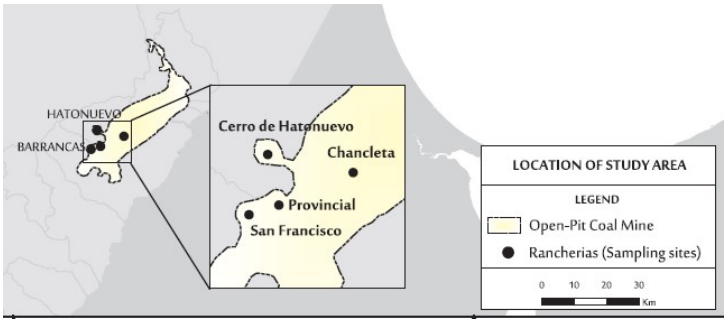
For instance, oil and gas extraction and coal mining have been associated with the emission of hazardous air pollutants linked to cancer and other long-lasting serious health outcomes. This risk results in an additional economic burden for affected families. Research on this topic is still incipient, and further detailed investigation is required to causally link these effects to mining (Espitia-Pérez et al., 2018; Garcia-Gonzales, Shonkoff, Hays, & Jerrett, 2019).

Likewise, particular matter from coal mines is usually composed of a complex mix of particles that differ in size and toxicity levels. Depending on its composition, the type of health effects varies, potentially being more hazardous or chronic than here estimated (Gehring et al., 2015). Incorporating this into the analysis is unfeasible since Colombia has an incipient number of studies that analyse the type of particles and their effect on the population's health. The scarce existent studies have predominantly focused on underground mines, which result in relatively lower health impacts than open-pit mines (González-Martínez et al., 2020)

Furthermore, working in mining has multiple health risks. For instance, a prevalence of 39% of pneumoconiosis – an uncurable respiratory illness) was found by coal mine workers. A considerably higher number than that found in previous studies in China (6%) and the United States (4%) (Varona et al., 2018). There is a risk of accidents that can't be overlooked, particularly those regarding explosions within the mine. According to the National Mining Agency, an average of 100 workers are killed yearly in mine accidents, mostly associated with landslides and poor ventilation. Recently, in March 2023, 21 workers were killed in a coal mine explosion (AbcNews, 2023).

In addition, hazards associated with fuel transport, particularly oil, can present a potential risk for nearby communities. In 2018, an oil spillage affected the Magdalena River. As a result, in line with research linking health issues with oil spillages (Laffon, Pásaro, & Valdiglesias, 2016), families near the river reported and had to be treated for vomits, headaches, and dizziness (National Geographic, 2018).

**Box 5-2. Coal Mines and Health Impacts In La Guajira**




Communities nearby open-coal mines in La Guajira

Source: Espitia-Perez et al. (2018). Cytogenetic instability in populations with residential proximity to open-pit coal mine in Northern Colombia in relation to PM10 and PM2.5 levels

Espitia-Pérez et al (2018) studied the relationship between health issues affecting population living close to close-pit and fine particulate matter ($MP_{2.5}$) levels around the mining areas. The results show that Indigenous and Afro-Colombian populations living nearby coal mines for at least 18 years in La Guajira present a higher probability of developing cancer than compared to similar populations living elsewhere. The particulate matter is found to contain combinations of inorganic elements and high concentrations of organic matter that have previously been associate with cancer. Considering this evidence, the authors conclude living in proximity of a coal mine in La Guajira increases the risk of manifesting cancer and other mining-related diseases.

## 5.5 Environmental Impact

**Additional environmental impacts, mainly affecting vulnerable and indigenous communities are associated with existing and closing mine sites.**

While fossil fuel extraction might bring economic welfare in the form of jobs, it has also generated a wide range of environmental impacts sourcing from the active and inactive or abandoned sites. In fact, water, soil, and air pollution, degradation of agricultural land, deforestation, contamination of marshes, a decrease in fishing resources, vibrations, and earth slips that come with fossil fuel extraction entail an active risk for the country's flora and fauna megadiversity and an abrupt decline in the welfare of people living nearby a production site (Andrade-C., 2011; Lavaux, 2006).

Up to 5.6% of the yearly deforestation over the 2001-2018 period is associated to mining of coal, gold and other materials (González-González et al., 2021). From this, coal is underscored as one of the materials that involve most forest clearing. The rate of deforestation extent related to legal coal mining almost tripled in recent years from its average rate over the 2001-2015 period (González-González et al., 2021). In 2018 an oil spill in the Santander region which resulted in large damaged for the region's ecosystem as well multiple families affected. Ecopetrol was sanctioned to pay over 5,000 million COP for the damages (ANLA, 2018). This profoundly impacted families who relied on the affected river for food and economic activities.

Most communities threatened by environmental degradation already face poverty, inadequate health service provision, and lack representation at the national level. Indigenous communities haven been disproportionately affected due to their high dependence on natural resources for subsistence (Rodríguez-Zapata & Ruiz-Agudelo, 2021). For instance, due to the extraction of coal, the Wayúu indigenous community in La Guajira has struggled with drinking water contamination. In fact, they have access to only 0.7 litres of water per capita per day despite the United Nations requirement of 50 litres (Betancur et al, 2016). In contrast, El Cerrejon coal mine, operating in the same region, consumes 17 million litres of water every single day (Gonzales, 2016 as cited in Betancur et al, 2016). In addition, a lack of regulation surrounding the measurement of pollution by control agencies, the disappearance of water sources, and irregular processes for the diversion of riverbeds, stemming from procedural failures of environmental authorities to protect the rights of the community (United Nations, 2020).

While these impacts can't be overlooked, their quantification and monetisation is not a simple task. On the one hand, many follow a distinct probability of occurrence, dependent on the level of government's policing and companies' practices. Issues of value incommensurability and plurality further raises the question regarding the appropriateness of assessing this issue solely through an economic lens (Cardoso, 2015). However, its consideration sheds a light onto the associated benefits of stopping the fuel extraction and on the environmental liabilities that companies should exert after the

mine closure. Today, the latter is only found in the form of non-binding recommendations (ANLA, 2022).

**Box 5-3. Environmental And Social Impact of Oil Extraction in Meta**

Environmental damage of mining activities in Colombia
Source: Semana (2021) Radican proyecto para endurecer penas para quienes atenten contra el ambiente

Meta has suffered multiple environmental losses due to oil extraction over the years. Particularly relevant has been the detrimental effect in water resources. Ecopetrol, Colombian primary petroleum company, was blamed of limiting water supply for riverside population and polluting water streams, damaging the ecosystem and significantly decreasing fishing resources (El Tiempo, 2021). Oil exploitation in the region has also been linked to soil destabilisation which can result in underground water pollution and rural road blockages (Ambiente y Sociedad ONG, 2017). Oil spills have also affected the region, resulting in the pollution and degradation of water and land (Semana, 2017), These impacts directly affect the economic activity of the people, particularly those who subsist on fishing, agricultural activities, and tourism. As a result, oil extraction has produced a generalised discontent in the region, especially among the rural population. This has led to mobilisation and blockages of exploration activities, which enhances social conflict and is also detrimental for the overall economy of the region (Ambiente y Sociedad ONG, 2017).

## 5.6 Social Impact

**A halt in fossil-fuel extraction activities places an opportunity for restoring the cultural identity of the indigenous population.**

In Colombia, the relationship between indigenous communities and mining often involves tensions, conflicts and active opposition from the population (Arbeláez-Ruiz, 2022). In general, the displacement of Colombian indigenous communities caused by fossil fuel companies who render ancestral land unliveable by contaminating vital resources, such as water supplies, has a notable effect on the integrity of indigenous communities, their culture, and survival (Lavaux, 2007). It also can increase intergroup conflict, negatively effecting the well-being of individuals and groups.

As oil and gas and coal mines are closed, indigenous communities would have an opportunity to reclaim the lost territory and heal divisions created by the extractive industry. As underscored by the Colombian government, new technologies and activities resulting from an integral energy transition would potentially better adapt to indigenous cultures while enhancing their well-being (Ministerio de Minas y Energía, 2022).

**Box 5-4. The Wayuu Cultural Loss**

Construction on Guajira-1 wind farm, October 2021 | Andrés Bernal Open Democracy
https://www.opendemocracy.net/en/democraciaabierta/colombia-wind-power-guajira-en/

In La Guajira, the Wayúu people's ancestral territory was recognized by the Colombian government as reserve land from the late 1980s but excluded coal-rich areas (Betancur et al, 2016). This resulted in a long history of "failure to consult indigenous peoples regarding mining activity on their territories" leading to their systematic "exclusion from the lands necessary for their survival, seriously affecting their environment and their physical, social, cultural and economic integrity" (Betancur et al, 2016, p. 5). They have been mainly affected by El Cerrejon coal mine, which has deteriorated its environment to the point of risking their livelihoods (Betancur et al, 2016). Targeted compensatory mechanisms have created division in the community between those who support the mining activities and those who oppose it (Gilbertson, 2020).

**The culture surrounding mining activities can heighten the costs of the transition.**

Mining activities play a role in defining the identity of families that depend on this activity, creating a generational mining culture. This usually occurs when the mining activity has been critical in constructing an associated community over several generations (Bosca & Gillespie, 2018). Thus, it goes beyond solely economic reliance on the activity, but it's built around the social and cultural context.

This phenomenon has been typically studied surrounding coal mining activities, often found to be constructed around the "social, economic and often physical isolation associated with cultures of coal extraction" (Bosca & Gillespie, 2018, p. 736). Mining activities play key a role in defining the identity of families that depend on this activity. It creates a generational mining culture that goes beyond solely economic reliance on the activity, but it's built around the social and cultural context. Ignoring these cultural phenomena results in overlooking place-specific threats to the energy transition process that could exacerbate the costs of the process. Therefore, it's critical that potential generational mining culture is identified and understood, and steps to be taken reintegrate these communities into the broader cultural context of Colombia.

**The closure of extraction sites can result in migration flows that erode the well-being of other communities.**

The phase-out of fossil fuel extraction activities could increase migration of the population towards regional centres, especially in areas with low economic diversification. Internal migration, primarily related to conflict, already presents a challenge, especially for the displaced population (Franco Torres, 2020). If no measures are taken, rapid migration of many people associated with the transition wouldn't allow for adapting the existing systems, stressing public services such as water, health, and education. It can also exacerbate social tensions, increasing instability and insecurity (Strambo, 2018). Thus, the reemployment of the workers within the same area would be a critical goal to avoid potentially disruptive migratory movements.

# 6 Policy Recommendations

The results of the cost-benefit analysis help to inform a series of policy recommendations for Colombia to consider when moving forward with its energy transition. The focus of our recommendations is centred around the pace of the transition, how to foster a just approach and how to adopt cost-effective strategies.

## 6.1 Transition Pace

**RECOMMENDATION 1: Divest from extractive industries at a moderate pace to minimize premature job and revenue loss.**

The pace at which the transition occurs is vital in ensuring its equitability and overall impact. A BAU approach will not facilitate Colombia's 2050 net zero goal and the uncertainty in the global demand for fossil fuels poses a risk to Colombia's fiscal health. These factors indicate that some level of divestment from extractive industries is a required step in Colombia's transition.

The role of the net zero goal in deciding the pace of the transition depends on additional policies Colombia chooses to enact. It will be necessary to assess the level of production and exploration that must be reduced to meet those commitments. However, it mustn't be forgotten this would account for only 7% of the country's total GHG emissions. In turn, changes in the activity would entail substantial costs or benefits to the affected people.

As underscored by the analysis, Colombia is posed to lose up to 100.000 jobs throughout the transition, from O&G, Coal and indirect jobs in other sectors. A moderate transition would imply the premature loss of 12,000 jobs in the first five years. Contrastingly, an expedited scenario would increase this number to 19,000 premature jobs lost within the same period. An expedited transition would require significant political alignment and coordination between several stakeholders, including industry, politicians, and communities. While this scenario could occur under the right circumstances, it is unlikely in the context of Colombia's political economy and state capacity; many drastic fiscal, labour, justice, environmental and regulatory reforms

would need to be simultaneously undertaken. A moderate approach for fossil fuel extraction phase-out is recommended. The pace must allow a gradual reduction of exploration and production at a rate is feasible for the job market to absorb the changes.

By starting the long process of transitioning away from fossil fuel and resource extraction at a manageable rate, Colombia will begin to usher in a new economic status quo, shifting jobs away from polluting industries and towards renewables without the unjustifiably high costs for people. Another benefit of taking a moderate approach to the transition is giving Colombia time to invest in and build up their renewable energy industry, a source of new jobs, economic stimulation, and an avenue to recoup the revenues lost from extractive industries. A moderate pace is necessary to ensure funds can be reallocated in such a way that social services and programs can adapt to decreased funding.

## 6.2 Fostering a Just Transition

**RECOMMENDATION 2: Restructure royalties' allocations to fund infrastructure and research needed to facilitate a just transition.**

The Colombian Government has set a series of climate change policies to foster a just transition. In the recent Investment Plan (IP) for the Climate Investment Funds (CIF), led by the MME, Colombia is expected to allocate 70 million USD from their budget to financing new technology and businesses for the energy transition. This plan aims to achieve emission reduction, scaling up renewable technology, enhancing related infrastructure, and promoting the just energy transition (CIF, 2023). CIF also analysed that limited financing to public infrastructure is still one of the hindrances to the project. For instance, wind energy generating projects which were originally expected to operate in 2023 are expected to be postponed due to construction delays with the transmission line. This delay is partly influenced by inflation, local currency devaluation, high shipping and raw materials costs. To overcome this uncertainty, a more stable and diversified way of financial support from the government needs to be prepared.

In the medium term, reinvesting coal and oil royalties to support these approaches can be an effective option for stable financing. The Stockholm Environment Institute proposed a policy recommendation that would see Colombia spending the extra royalties earned from coal's rising prices on research to promote the best economic alternatives for each department that is dependent on mining (Yanguas et al., 2021, p. 20). Additional circumstances such as current geopolitical tensions in Russia and Ukraine also enable them to increase their profit and royalties with the increase of the international price of coal. Under this situation, Colombia's coal industry has benefited from this higher export price of national coal supply and increasing royalties on coal could serve to counter some of the decreases in royalties that accompany the energy transition. Royalties can be utilized as a financial source to smooth the transition to other energy sources, as opposed to a source for increased trade-offs from transitioning (see Section 5.2).

In the long term, the energy transition will eventually decrease the royalties from coal and gas. Regions where coal mining and royalties account for a significant portion of the economy, an energy transition lacking support plans will lead to insufficient social investment for the society and communities. Some regions such as Vaupés and Chocó that will experience these financial shocks have a very high proportion of indigenous groups compared to areas that are less affected (see Figure 5-6).

The logic is that, if currently the trade-offs from divestment in fossil fuels are so large, it is because those funds are being used as current spending or investment in other areas, rather than as a way to transition more easily towards renewables. If a larger portion of the social spending is shifted to the general budget, and royalties are increasingly used to fund renewable technology, a moderate transition would have fewer net costs likely to materialise.

**RECOMMENDATION 3**: **Encourage a dialogue process between communities, mining companies, and the government to ensure needs are met.**

A dialogue between the different transition stakeholders must be enabled to allow for compensating for the costs and grasping the benefits identified in the CBA. Therefore, Colombia must increase its regulation surrounding the constitutional requirement to recognize and highlight the concerns of all communities who stand to bear losses.

For one, the CBA underscored disproportionate costs borne by the indigenous population associated with mining activity. It is, therefore, crucial that indigenous communities are given a platform to share their concerns and that these concerns are readily acted upon to minimize unrest and maximise the benefits surrounding the energy transition. In this matter, Colombia has committed to honouring Free, Prior and Informed Consent (FPIC), a core international principle championed by the United Nations and the International Labour Organization in ILO Convention 169, outlining the need to protect the rights of indigenous people and other ethnic groups. In August 1991, Colombia protected and secured indigenous people's rights by ratifying the Colombian Constitution and ILO Convention No. 169 (Iseli, 2020, p. 265). These principles pave the way for the participation of indigenous communities in decision-making processes regarding administrative and legal measures that could potentially affect their way of life, territories, and resources. Colombia has made efforts to allow for community consultation and the raising of concerns. For example, consultation has occurred concerning the activities of El Cerrejón coal mine in La Guajira and the Drummond coal mine in César. However, the concerns and wishes of indigenous people have not affected outcomes. It is often the case that economic and extractive activities proceed despite significant pushback from local communities during consultation processes. This diminishes trust and negatively affects a community's resilience and ability to cope with subsequent challenges (Rodriguez et al., 2021, p. 11). In fact, indigenous leaders have noted that the "FPIC has never been operationalized to actually include their input in

the decision", only to ensure mechanisms for their input to be heard (Iseli, 2020, p. 270).

As lengthy discussed in Section 4.5, the transition's impact is composed of tangible impacts (such as job loss) and intangible ones (such as losses in social cohesion and culture). While costs and benefits are similar across departments, the strategies for just transition can take different forms depending on the affected community. Therefore, the dialogues goals should include identifying the communities' values, how these values may be at risk in an energy transition and how to minimize these risks and account for potential losses in social cohesion and culture (Barnett et al., 2016, p. 977). Increasing the avenues for dialogue within communities through public forums, community boards, and offering community representatives a seat at the table is essential to ensure policies are centred around the needs of the community and minimize the potential for unrest.

Beyond normative ideas and non-binding conventions surrounding consultation, Colombia must more clearly implement the suggestions, concerns, and critiques raised by the community to properly value the cultural costs of an energy transition. In alignment with ILO Convention 169, Colombia can do so through consultation that occurs before the start of a project; provides stakeholders with full, comprehensible information; utilizes the representative institutions of indigenous people; is representative of the larger community and their interests; and includes specific enforcement mechanisms, holding the government and private companies accountable not only to consult, but to implement findings.

Colombia's existing commitment to constitution with reference to indigenous and ethnic groups needs to be expanded to encompass particularly affected groups (for example, generational coal mining communities) in the context of a just energy transition and encourage dialogue within and between communities. Moreover, incorporating clearer regulatory measures, legal frameworks, and enforcement mechanisms will help ensure consultation is effective, leading to better outcomes for the communities affected and minimizing unrest. Consultation with real mechanisms to

encourage change will help ensure the energy transition does not detrimentally harm the wellbeing and culture of particularly vulnerable populations.

**RECOMMENDATION 4**: **Leverage existing capacities and economic diversification to offer training and reemployment alternatives.**

As illustrated by the CBA, the pace of the transition will define the number of premature jobs lost. These are composed of losses in mining and other related sectors. The latter, however, is expected to be of moderated magnitude. Colombia's mining sector has a relatively low linkage with other sectors. This is persistent even in mining-dependent regions (CCSI, 2019). Since 94% of the mined coal is exported, backward linkages – mainly composed of construction, land transportation, and storage purchases – are more prominent than forward linkages (UPME, 2017). Backward and forward linkages are lower than those in other sectors, such as industry, agriculture, transport, and services. Consequently, the main challenge is providing adequate support for the coal, oil and gas workers of the closing extraction sites and the surrounding communities.

As further discussed in Recommendation 5, an appropriate stimulation of the economy would see the emergence of new industries and jobs. However, training must be proactively offered to provide an adequate solution to workers. Colombia could leverage their already existing programs targeted at mining. Mining companies in Colombia are subject by Law[10] to prioritise local employees. To ensure locals hold the needed qualifications, the Ministry of Education regularly analyses the skills needed in mining and makes the information available to educational institutions (Mineducacion, 2023). Leveraging this analysis would allow the identification of skills gaps that need to be immediately addressed for affected workers to be re-employed. Moreover, its active use in years to come would allow for adapting the curriculum of schools and tertiary education institutions to adapt to the future energy sector needs.

[10] Law 685/2001, Article 251

The international experience has underscored the effectiveness of partnering with stakeholders to offer training and reemployment opportunities for affected workers in improving workers' well-being and mitigating social disruptions the transition might otherwise entail (see Section 2). A successful program usually responds to needs exposed by workers through unions or other organisations. In Colombia, Ecopetrol's diversification process towards hydrogen production (discussed in Recommendation 5) offers an opportunity for job reallocation within the same company for oil and gas workers. Additional support from the public sector would be necessary for mining workers of companies that might not be diversified enough. Partnering with educational institutions that, by law[11], receive royalties for technology transfer could result in a cost- effective training strategy. These programs should also be further extended to account for the gender gap in the energy sector and overlooked indigenous communities (see Section 4.5).

Targeted measures are required for workers and affected community members that might suffer from the local economic disruption. This requires planning and resource accumulation that can be later distributed through early retirement and compensation schemes. The CBA results (Section 4.5) exposed a significant decrease in the government's revenue associated with the mining transition. Therefore, the pace of the transition and the level of fiscal income diversification must consider this expense.

## 6.3 Adopting Cost-Effective Transition Strategies

**RECOMMENDATION 5**: **Diversify Colombia's fiscal income sources to mitigate the loss of revenue trade-offs from the transition.**

Amid the loss of government revenue during the transition, Colombia will need to adapt fiscally to the new circumstances. This would allow the maintenance of the social expenditure level and reach the investment levels required to carry out a successful transition. Colombia will face up to 35 billion COP of yearly revenue loss

[11] Law 685/2011, Articles 151 and 255.

(almost 3% of GDP) once they transition away from fossil fuel extraction (see Notably, the regulatory allocations for sustainability projects are comparatively small. The current royalties framework is designed to be spent on human development with little regard for the role that the mining proceeds in funding their future renewable alternatives. No matter the pace of the transition, these revenues will vanish, leaving education and health unfunded, and renewable infrastructure underdeveloped.

Figure 5-7). The ultimate magnitude of the losses depends on the pace of the transition. Namely, adopting a moderate approach would allow more time for fiscal policy to adapt (see Recommendation 1). Beyond the macroeconomic challenges this poses, compromising on spending could see Colombia's human development path severed. Moreover, the poorest departments are most relatively affected by reduced central government revenues and royalties. This population is also the most rural, ethnically diverse and, therefore, underrepresented (Figure 5-6).

Fiscal diversification has two avenues: (i) replacing the existing revenues and rents with new activities and (ii) extending the tax base. Diversification by (i) serves the dual purpose of minimizing job loss and economic downturns and mitigating social unrest that may occur during the transition. One such example is already in motion: Colombia is pursuing the development of green and blue hydrogen infrastructure and the internal market framework, with Ecopetrol currently piloting projects. The country is well-positioned to leverage the technologies and expertise of oil and gas companies in this new market (Mantilla and Santas, 2022). Existing pipeline infrastructure in La Guajira could allow Colombia to successfully transport hydrogen out and within the country. Alongside this, it would reduce friction in the labour market for the workers in fossil fuel industries.

Uncertainties regarding how much hydrogen could supplement government revenues, makes avenue (ii) increasingly necessary. Cardenas & Orozco (2022) highlight three policies to support fiscal policy amid revenue loss: carbon pricing, green fiscal rules and carbon offset markets. Regarding carbon pricing, there is still scope for increasing the existing carbon tax, as it is lower than its OECD peers. Furthermore, a latent

opportunity for decreasing oil subsidies exists. The backlash received by governments that have undergone such policies reasonably dissuades policymakers. Green fiscal rules entail modifying the current fiscal instruments to allow for environmental liabilities to be accounted to enable further green investment. A carbon market would allow countries to monetise existing forests and provide incentives for reforestation. This is further discussed in Recommendation 6.

**RECOMMENDATION 6: Address the most significant polluting sectors to ensure an effective decarbonisation.**

The CBA shows that the carbon emissions avoided by the closure of mining activity are negligible compared to other sources. Ensuring a cost-efficient road to net zero requires Colombia to focus on policies addressing the use of fossil fuels in road transport and in the residential sector, as well as deforestation.

Electrification is both a development (Section 3.4) and an environmental (Section 3.1) goal. Colombia's existing clean electricity matrix makes electrifying transport an effective way to reduce their carbon footprint. As it relates to GHG emissions, the benefits from the electrification of transport (17%) outweigh those of accelerating the phase-out of fossil fuel production (7%). While estimating the total cost of electrifying transport is beyond the scope of this study, the following considerations can be underscored. First, electrification constitutes a high cost (Cardenas & Orozco, 2022b), high reward policy. Secondly, developing a regulatory framework and incentives for infrastructure and retrofitting of the transport fleet is key to reducing carbon emissions and improving air quality (IDB, 2021; Ministry of Environment and MME, 2019). Thirdly, the costs of electrifying transport are typically shared between public and private sectors, thus, corresponding to a relatively cheaper measure to encourage.

Regarding the electrification of the residential sector, the lack of grid connection in Colombia can be addressed through the promotion of renewable distributed generation. As a result, less developed and remote areas would increase their access to electricity at no carbon emissions. In addition, moving away from oil engines allows the

communities to forgo fuel dependence for electricity. For instance, Peru implemented various renewable-based electrification projects to serve rural communities where the expansion of the national grid was deemed unaffordable (Juanpera, Domenech, Ferrer-Martí, Garzón, & Pastor, 2021). The Peruvian case is an example of the potential of renewables in electrification and the relevance of community engagement and institutional support in the success of the projects. Colombia has also expressed interest in distributed generation and community engagement. Especially due to its alignment with indigenous cultural values (Ministerio de Minas y Energía, 2022). However, these projects are often deemed too costly, as they lack the scale to drive costs down.

Lastly, several analyses (IDB, 2022; Cardenas & Orozco, 2022a; MME, 2022) coincide with our assessment of the need to address AFOLU emissions. As previously discussed in Section 3.1, the two main AFOLU items contributing to GHG emissions are change in land use (deforestation) and livestock (enteric fermentation). Reduction of the methane produced in enteric fermentation can be attempted with market incentives and technology, but the policy roadmap is unclear. On the other hand, strategies to address deforestation are well documented and fit cost-effectiveness as well as climate and environmental justice criteria. Expanding ecological restoration, actively reducing illegal deforestation, and enforcing management of protected areas can help reduce these emissions (Cardenas & Orozco, 2022a, p. 21), as well as the establishment of Carbon-offset markets, which require substantial public support in the early phases. These undertakings will help Colombia reach their net zero goal while also preserving the region's biodiversity, an asset that is likely undervalued in any analysis,

# 7 Conclusion

Throughout our research we sought to understand how the energy transition may affect productivity and inequalities across Colombia, and what actions should be taken to avoid the deepening of any socioeconomic gaps so that no one is left behind. Through the development of a cost benefit analysis, it was determined that there were several factors that are detrimental to assessing the impacts of the energy transition. The key factors to the energy transition include job loss, revenue from royalties, social and cultural effects, and environmental and health impacts. Depending on the pace of the energy transition job loss in departments that are highly reliant on coal and oil production could see expedited job loss. Therefore, departments such as Meta, could benefit from added social benefits including unemployment insurance, re-skilling programs and financial compensation. Similarly, those departments that are highly reliant on coal and oil production will see significant decrease in revenues from royalties received from mining activities. It is recommended to reconsider the royalties' structure to allow for redistribution to areas that will be most affected by the transition to help compensate for the loss of revenues. Further to the inequalities in job loss and royalty distribution it is crucial to examine any inequities that are imposed on indigenous and GCMC to properly value the cultural costs of an energy transition. Lastly, an energy transition presents environmental and health benefits for all Colombians. Throughout this analysis the costs and benefits of a transition have been assessed and while each factor of the transition presents unique challenges and opportunities it is crucial to apply a people centric lens to the policies and actions to foster a truly just energy transition.

# 8 Appendix

## Appendix A. CBA Variables and Assumptions

**Table 8-1. CBA Variables and Assumptions**

| Variable | Description | Assumptions | Estimation Strategy |
|---|---|---|---|
| **Direct job loss** | The income that is lost from the people become unemployed in the sector, and who don't find a job within the year, and income lost from people who find a worse job an become sub employed | - People who become reemployed earn 75% of their previous income.<br>- People in mining earn the average income | $= \left(\frac{\text{output}}{\text{workers}}[sector]\right) * (scenario\ effect\ on\ production) * (department\ income)$ |
| **Indirect job loss** | The lost income from the people that become unemployed in the rest of the economy, and who don't find a job within the year. | The linkage multiplier is obtained from the DANE 2017 input-output matrix. A similar economic structure is assumed for every department. | = direct job loss * linkage multiplier |
| **Tax and capital revenue** | The change in taxes collected and capital revenue obtained from POEs. | The taxes and capital revenues are proportional to the sector's size | Data for oil & gas revenues is obtained from Asociacion Nacional de Petroleos, and from UPME for coal. |
| **Royalties** | Change in royalties collected from extractive activities. | Royalties' distribution | = total royalties * share by sector * scenario effect on prodution [sector] |
| **Reduced CO2** | Change in CO2 emissions due to changes in energy production. | - Less mining is translated in a decrease in fuel burning.<br>- The benefit associated to the reduction differs on each department, dependent on their Climate Risk index, and can be accounted for immediately. | = emission factor * change in fuel production * social cost of carbon * climate risk index |
| **Health benefits** | Avoided deaths and health issues associated with the reduction of non-CO2 emissions | Closing a mine has an impact on the population of the nearest city from where it's located. | = particulate matter emissions * health risk * statistical value of life |

**Table 8-2. Cost, Risks, Benefits and Opportunities of the Transition**

| | Costs | Risks | Benefits | Opportunities |
|---|---|---|---|---|
| Economic | Loss of Central Gvt revenue** | Volatile demand for minerals due to technological change | Increased demand for minerals and its value chain | Green and blue hydrogen |
| | Loss of royalties ** | Internal long-term demand for oil and gas | Energy efficiency gains from localized production | Specialize in energy intensive industries |
| | Income / job loss* | Energy security – Gas and Oil supply; Stability and reliability of renewables | Diversification of the economy – from extractive to manufacturing, or towards exploiting different resources | Payment for offsets and environmental services |
| | Less foreign currency | | | Bio-inspired engineering R&D |
| | CapEx to replace high-carbon technologies | | | Ecotourism |
| Social | Unequal regional economic effects* | Loss of culture (new projects interfering with indigenous territory) | Health damaging pollution avoided | Transferable skills from oil and gas to renewable energy sectors |
| | Less local social investment** | | Distributed electricity production (access to electricity in rural/disconnected places) | Engagement of the community in distributed generation projects |
| Environmental | | | Biodiversity conservation | Deforestation prevented |
| | | | Reduced $CO_2$ emissions | |

**Table 8-3 Emission Factor for Carbon Emissions**

| Type | Fuel | Emission Factor | Unit | Source |
|---|---|---|---|---|
| **Production** | Oil | 80.92 | kgCO2-eq/boe | (IEA, 2020) (median value) |
| | Gas | 125.61 | kgCO2-eq/boe | (IEA, 2020) (median value) |
| | Coal | 160.45 | kgCO2-eq/ton | (UPME, 2022; US-EPA, 2022b) |
| **Burning** | Gas/Oil | 453.34 | kgCO2/boe | (IPCC, 2006) (Gas/Diesel Oil-Table 2.2) |
| | Coal | 288.02 | kgCO2/ton | (IPCC, 2006) (Anthracite-Table 2.2) |

## Appendix B. Health Impact Methodology

The quantification of the mortality effect due to pollution requires to know the risk associated to a unitary change in air quality, known as the unitary risk of mortality or $\beta$-coefficient. This unitary risk for mortality is derived from epidemiological studies that relate pollution with health outcomes. In this study, we calculate the unitary risk from relative risk (RR) reported in the meta-analysis of epidemiological studies conducted by Pope et al (2020). To do this, we assume the relationship exposed in Equation 8-1.

**Equation 8-1 Relative risk main assumption**

$$RR \cong e^{-\beta \times \Delta C} \rightarrow \beta \cong \frac{\ln(RR)}{-\Delta C}$$

Source: (US-EPA, 2022a)

Equation 8-2 shows how to calculate the effect in mortality using the calculated $\beta$. Where $\Delta Y$ is the change in the number of deaths, $\beta$ is the unitary risk associated to a change in air quality, $\Delta C$ is the magnitude of change in pollution concentration associated to the mining activities, $P$ is the affected population, and $IR$ is an estimate of the average share of people who die in a given year.

**Equation 8-2 Health impact function**

$$\Delta Y = (e^{\beta \times \Delta C} - 1) \times P \times IR$$

Source: (US-EPA, 2022a)

Moreover, given that the unitary risk is very small, the equation is linearized to simplify its calculation, as shown in Equation 8-3.

**Equation 8-3 Health impact function, linearized**

$$\Delta Y = (e^{\beta \times \Delta C} - 1) \times P \times IR \cong \beta \times \Delta C \times P \times IR$$

Source: (US-EPA, 2022a)

The $\beta$-coefficient (0.77%) is calculated from the results of a thorough meta- analysis conducted by Pope et al (2020) which comprises multiple types of populations and accounts for all mortality causes associated with pollution. The change in pollution

concentration ($\Delta C$) is estimated using the change in fuel production of each scenario and the value associated to mining shown in Table 8-4. The value associated to coal mining was converted from emission to concentration using a concentration-emission factor of 249 ton/(μg $MP_{2.5}/m^3$) (Ministerio del Medio Ambiente de Chile, 2017). The considered population is the department's population where the particular mines were sited, and the incidence rate is taken based on data from the Global Burden of Disease (GBD) studies 516.32 deaths/100,000 population (IHME, 2022).

**Table 8-4 Values for changes in the concentration of fine particulate matter**

| Activity | Value | Unit | Source |
|---|---|---|---|
| **Gas and oil mining** | 193 | (μg$MP_{2.5}/m^3$)/boe | (Gonzalez et al., 2022) |
| **Coal mining** | 0.006 | kg$MP_{2.5}$/ton coal | (EEA, 2019) |

The calculated change in premature mortality is valuated through a statistical value of life calculated for Colombia. We calculate this number following the methodology presented in (World Bank Group, 2021b).

**Equation 8-4 Benefit-transfer function**

$$VSL_{Col} = VSL_{OECD} \times \left(\frac{GDPPC_{Col}}{GDPPC_{OECD}}\right)^{\epsilon}$$

Source: Adapted from (World Bank Group, 2021b)

Where $VSL_{Col}$ is the estimated value of statistical life for Colombia, $VSL_{OECD}$ is the average value of statistical life for OECD countries with appropriate studies (3.83 million USD), $GDPPC_{Col}$ is Colombian GDP per capita (14,649 USD), $GDPPC_{OECD}$ is the OECD countries GDP per capita (46,103 USD) and $\epsilon$ is the income elasticity (0.8). All prices are in PPP for 2021. $VSL_{Col}$ in PPP is then converted into COP by multiplying it with the PPP exchange rate in Colombia in 2021 (1,352 COP/USD).

# Appendix C. Key Considerations

**Table 8-5. Key Considerations for the Energy Transition**

| Consideration | Implications |
|---|---|
| **Environmental Impact** | • The most evident benefits are environmental, and, locally, involve less pollution which contributes to health issues, improved biodiversity conservation.<br>• The global externality of emissions, if internalised, is accounted as a benefit when reducing the use of fossil fuels. The most common measure is the "social cost of carbon". The value used is proposed by Cepal, 2016), which finds an average value of 25 USD per ton of CO2, with values that range from 6 USD per ton CO2 to 100 USD per ton of CO2 |
| **Ethnic Inequalities** | • The transition process promises to further climate and energy justice, which overlaps with ethnic inequalities in Colombia.<br>• Energy production, energy availability, and economic activity in Colombia in which peripheral regions, where ethnic communities tend to concentrate, bear the negative externalities of extraction and production, have disperse economic activity and average low access to energy.<br>• The shift from oil, coal, and gas powerplants to a cleaner and more distributed kind of generation with solar and wind stands to benefit otherwise disadvantaged peoples. |
| **Other Considerations** | • The success of technology development and deployment is dependent on international demand and the prices of oil and carbon, the expansion of offset markets, the development of hydrogen technologies and infrastructure.<br>• If Colombia manages to successfully implement its plans on policies such as ecotourism, tackling deforestation, promoting R&D, and capitalising the energy potential of solar and wind in various peripheral regions.<br>• Socially the extent to which skills in the affected industries are transferable and workers are not left behind, and whether highly specialised and dependent municipalities are able to readapt is also a risk posed by the transition process. |

# Appendix D. Cultural Methodology

**Box 8-1. Social Risk and Opportunity for Mining Phase-Out**

**Characteristics of mining community**

- **Economy**: "Company town" Economic predominance of mining
- **Society**: Physical and geographical isolation from the outside world and the whole-close knit and interlocking collectives based on shared history
- **Social life**: "Workmates" dangerous, unhealthy strengthens the cohesion among workers
- **Family**: Sharp division of men's and women's world

**A systematic approach to social characteristics of mining communities (Bulmer, 1975)**

| Level of analysis | Source of Change: Exogenous | Source of Change: Endogenous |
|---|---|---|
| Social structure | **Institutions** | **Collectivities** |
| Social interaction | **Social condition of action** | **Ends/definition of situation** |

Bulmer (1975) suggests four approaches with two distinctions for changing mining communities: the source of the change ('exogenous' vs 'endogenous') and the level of sociological analysis ('social structure' and 'social interactions'). This framework can be used to categorize mining communities into: Economy, Society, Social life, and Family.

As the energy transition begins, the main source of the change will come from the outside world (exogenous change), leading to institutional changes in the social structure. Social conditions will change slowly as coal activities change. The collapse of the mining-dependent localities and the solidarity between workers can dissolve social capital and trust. Changes in the social status of the members can create generational conflict or domestic violence. Changes in social structure will open new opportunities for women to participate in economic activity and create independence.

# Appendix E. Key Strategies for a Just Transition

**Table 8-6. Key Strategies for a Just Transition , with Examples**

| Strategy | Example | Insight |
|---|---|---|
| **Targeted programs** | Brazil removed the subsidies for liquified-petroleum gas, and introduced a gas voucher targeted at low-income households (Saget et al., 2020).<br><br>In light of coal mines closure, unions signed an agreement with the Spanish government to allow an early retirement for older workers and an indenisation of 10,000 EUR for young workers (Saget et al., 2020) | Programs designed in consultation with stakeholders and targeting affected groups can mitigate the negative consequences of the transition and foster people support. |
| **Active job reallocation** | Following the shutdown of coal powerplants announcement in Chile, worker unions and energy companies compromised in offering job opportunities and upskilling the main contractors affected (diarioUChile, 2022; Enel, 2022; Sindical, 2021).<br><br>In Ruhr, Germany, the local government cooperated with a vocational training company in developing a reemployment strategy for each worker affected by coal mines closure (ETUI, 2019) | The interaction between the government and the private sector is crucial in delivering tangible solutions for the workers. Avoiding the negative impacts of the transition will require providing job alternatives that translate into better working conditions for the affected communities |

| Strategy | Example | Insight |
|---|---|---|
| **Skill development** | The German government has established a range of education and training programs to support the development of skills needed for the energy transition, including vocational training, university courses, and professional development opportunities (Unnerstall, 2017).<br><br>The Canadian "Energy Advisor Recruitment, Training and Mentorship" collaborates with organizations to offer tangible, hands-on training and guidance. It predominately targets underrepresented groups (Government of Canada, 2023) | Skills creation requires the cooperation of stakeholders to identify new occupations, implement training programs that address skill gaps, and support workers in transitioning through upskilling and reskilling. Adapting general education at the university and school level is crucial to developing flexible workers with cross-cutting skills. To avoid biases, it is vital to identify clusters of affected individuals beyond highly educated and labour market-attached workers. |
| **Addressing gender gap and informality** | The Chilean government launched the program "Energia+Mujer" to promote women's participation in the country's energy transition by executing diagnosis and encouraging the collaboration and commitment of stakeholders (MinEnergía Chile, 2023) | The transition poses an opportunity to create programs that promote the participation of underrepresented groups and reduce informality. This requires creating programs that encourage commitment from relevant stakeholders. |
| **Foster innovation and investment** | In diversifying its economy, Chile has been investing in green-hydrogen research and workforce capacity, which would foster investment and job creation in the country (MinEnergía Chile, 2020) | Creating economic opportunities is critical to absorb the job loss and ensure financial health. Exploring new market opportunities and promoting investment requires a sound policy framework in line with the country's comparative advantages and energy trends. |
| **Supporting the community** | The Spanish coal mine closure entails funding for environmental restoration. The plan includes an improvement of a wide range of services, including water treatment plants, public lightning and waste management (Saget et al., 2020) | The disproportionately damaged communities need to be identified and compensated in ways that foster a permanent improvement of life quality. |

# Appendix F. Capstone Project Terms of Reference

## Capstone Project Proposal – UNDP Colombia 2022-2023

### Organisation

United Nations Development Programme (UNDP). National Human Development Report. Bogotá, Colombia

### Project Working Title

A fair, efficient, and people-centered energy transition in Colombia: challenges, barriers, and opportunities.

### Background

Last May 2022, the UN-Energy Action Plan Towards 2025 was presented establishing a collective action framework for almost thirty UN and international organizations, in order to achieve the widespread commitment that they assumed last September 2021 during the High-Level Dialogue on Energy. Following the goals set out in the Global Roadmap to ensure access to clean energy for all by 2030 and net-zero emissions by 2050, UN-Energy has committed to supporting, facilitating, and accelerating access to electricity for 500 million more people and the provision of non-polluting cooking systems for more than 1 billion people. It also aims to increase renewable energy capacity by 100% worldwide, eliminate plans for coal power production after 2021, create 30 million jobs in the renewable energy and energy efficiency sector, and double the annual investment in clean energy worldwide.

The United Nations Development Programme (UNDP) is a United Nations agency. UNDP's mandate is to end poverty and build democratic governance, rule of law, and inclusive institutions. More specifically, UNDP concentrates its work on three areas: i) sustainable development, ii) democratic governance and peacebuilding, and iii) climate and disaster resilience, helping countries to develop policies, leadership skills, partnering abilities, institutional capabilities, and to build resilience to achieve the Sustainable Development Goals (SDGs). In this context, UNDP looks forward to promoting a just energy transition which is a significant economic opportunity for all countries, including developing countries. UNDP aims to bring about a new way of thinking, doing business, and connecting people and knowledge to address today's energy and climate challenges.

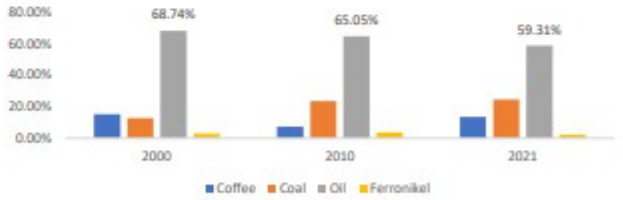
In addition to this, UNDP Colombia's Office has been developing its next **National Human Development Report (NHDR)** [1], which addresses both inequalities and productivity through the human development lenses. Through an interdisciplinary approach, the report aims to address and understand the channels through which the benefits of increased and sustainable productivity can be used to close social and economic gaps in Colombia. Likewise, it looks forward to understanding how less inequalities can have a positive effect on the countries' productivity and inclusive growth. In this context, it is crucial for the **NHDR** to understand how the energy transition may affect productivity and inequalities across the country, and what actions should be taken to avoid the deepening of any socioeconomic gaps so that no one is left behind.

Colombia is a country that historically has depended economically and energetically on resources such as coal and hydrocarbons. Oil has been the main export product for the last two decades and is the one that has generated the most income (See Figures 1 and 2). The foregoing has meant that this extractive activity has generated significant tax revenues, royalties, and other contributions during the last decades that have allowed promoting and sustaining social investment programs in Colombia. However, the country has prioritized the promotion of the energy transition, framed in the purpose of Law 1715 of 2014 and the CONPES[2] 4075 of 2022 to maintain a low carbon footprint, understanding that this would be a crucial facilitator of sustainable development and climate resilience (UN, 2021).

*Figure 1. Oil rents as % of GDP (2000-2020)*


Source: World Bank (2021)

*Figure 2. Main export products in Colombia. 2000, 2010 y 2021.*




Source: DANE (2022)

It has been found that the energy transition in Colombia has a high potential for the electricity generating sector, as it has a low share of coal in the national energy matrix and a large share of hydroelectric energy as a renewable resource (UPME, 2015). However, because

[1] The last National Human Development Report was published more than a decade ago in the country.

[2] CONPES are public policy documents in Colombia that are prepared to solve cross-cutting problems in whose solution several sectors participate and whose formulation is coordinated by the National Council for Economic and Social Policy.

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