CLIMATE CHANGE
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Implementation of Nationally Determined Contributions

Colombia Country Report

For our Environment

Umwelt Bundesamt

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Implementation of Nationally Determined Contributions

Colombia Country Report

by

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Introduction to the project

This country report is part of the "Implementation of Nationally Determined Contributions" (NDCs) project (FKZ 3716 4111 80), which considers NDC implementation in 10 countries: Colombia, Ethiopia, Georgia, Indonesia, Iran, Kenya, Marshall Islands, Morocco, Peru, and Viet Nam. This project places a special emphasis on identifying potential barriers to NDC implementation and mitigation potentials which could go beyond the current NDCs.

The country reports analyze the NDCs in terms of their robustness and coherence with other national or sectoral plans and targets, and put them into the context of additional mitigation potentials and other national circumstances. For countries where coal plays a critical role in consumption or national production, the analysis covers further details on this sector, including the economic relevance and local impacts of coal production or consumption. The content is based on available literature from research and public sector information on policies and institutions.

To be able to analyze the content in more detail, the authors focus the research on a number of relevant fields of action. The fields of action were selected based on historic and projected sectoral emissions development, comprehensive literature on GHG mitigation potentials, identified barriers and emissions reductions as well as feasibility, costs, and co-benefits.

The project was suggested and is financed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, supervised by the German Environment Agency and carried out by independent think tanks - NewClimate Institute and Wuppertal Institute. The country reports are a continuation of similar previous efforts (project numbers 3713 41 102, 3711 41 120, 360 16 022, 364 01 003 and 363 01 128) and aim to inform policy makers and the interested public about the implementation of NDCs in individual countries. The choice of countries is based on developing countries with which Germany works closely on climate change topics.

The country reports are scientific in nature, and all suggestions are derived by the authors from careful analysis, having in mind the individual backgrounds of countries. They aim to increase knowledge about implementation of mitigation potentials to meet the globally agreed goal of staying within a temperature increase of 1.5°C or well below 2°C above preindustrial levels, without intending to prescribe specific policies.

Overview

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List of abbreviations

AFOLU	Agriculture, forestry and other land-use
AILAC	Independent Association of Latin America and the Caribbean
BAU	Business as usual
BUR	Biennial Update Report
CAMACOL	Colombian Chamber of Construction
CAR	Colombia's regional environmental authorities
CAT	Climate Action Tracker
CDM	Clean Development Mechanism
CICC	Colombia's Intersectoral Commission on Climate Change
CONPES	Colombia's National Economic and Social Policy Council
COP	Conference of the Parties to the UNFCCC
CREG	Colombia's Energy and Gas Regulatory Commission
DANE	Colombia's National Administrative Department of Statistics
DNP	Colombia's National Planning Department
ECDBC	Colombia's Low Carbon Development Strategy
ELN	National Liberation Army
FAO	Food and Agriculture Organisation
FARC	Revolutionary Armed Forces of Colombia
FCPF	World Bank Forest Carbon Partnership Facility
FDI	Foreign Direct Investment
FEDEGAN	Federation of Colombian cattle ranchers
FENOGE	Colombia's Fund for Clean Energy and Energy Efficiency
FREL	Forest reference emissions level
GCF	Green Climate Fund
GDP	Gross domestic product
GHG	Greenhouse gas
GWP	Global warming potential
IDEAM	Colombia's National Institute of Hydrology, Meteorology and Environmental Studies
IDP	Internally Displaced People
IEA	International Energy Agency
IFC	International Finance Corporation

IKI	International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
INDC	Intended nationally determined contribution
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MADS	Colombia's Ministry of Environment and Sustainable Development
MME	Colombia's Ministry of Mining and Energy
NAMA	Nationally Appropriate Mitigation Action
NRCC	Colombia's Regional Climate Change Nodes
OECD	Organisation for Economic Co-operation and Development
OEF	Firm Energy Obligation
PAS	Sectoral mitigation plan
PDBC	Low carbon development project
PEMV	Strategic plan for monitoring and verification
PMR	Partnership for Market Readiness
POT	Territorial Development Plan
PROURE	Programme for the Rational and Energy Efficient Use of Energy and Other Non-Conventional Energy Form
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SIAC	Colombia's environmental information system
SISCLIMA	Colombia's National Climate Change System
TOD NAMA	Transport-oriented development NAMA
UN	United Nations
UNEP	United Nations Environment Programme (now UN Environment)
UNFCCC	United Nations Framework Convention on Climate Change
UNODC	United Nations Office on Drugs and Crime
UPME	Colombia's Mining and Energy Planning Unit
VIP	Housing units of priority interest
VIS	Housing units of social interest
WRI	World Resources Institute

1 Part I: Summary

1.1 Country background

Geography. Colombia is South America's fourth largest country and covers an area of 1.1 million km^2 (Cancilleria 2017). It is the only South American country that has access to both the Pacific Ocean and the Caribbean Sea.

Population. With a population of 48.6 million in 2016 (World Bank 2017), Colombia is the 28th most populated country in the world and the second-most populated in South America. Projections indicate that the country's population will grow to 53 million in 2030 and 54.7 million in 2050 (UN 2017).

Economy. Colombia is an upper middle-income economy and has seen economic growth rates of, on average, 4-6% between the early 1990s and 2007. In 2016, GDP growth stood at 1.7% and is estimated to reach 3.3% in 2018 (World Bank 2017).

Average nominal GDP per capita is moderately high at about USD 6,300 (2016). Based on the national poverty standard, 27.8% of the population are considered poor and wealth is distributed unevenly.

Political system. Colombia is a stable presidential representative democratic republic, with a directly-elected president as head of state (currently Juan Manuel Santos, serving a second mandate). The next general presidential election is scheduled to take place in May 2018 (Auswaertiges Amt 2017).

Economic and political interests often mingle. Political experts have claimed that Colombia is subject to clientelism and vested interests of powerful economic stakeholders such as the coal and mining industries. Columbia's corruption levels remain high, legal enforcement is often weak and inequality is a persistent challenge (Briscoe et al. 2016).

Armed conflict. Following an over 50-year conflict with the Revolutionary Armed Forces of Colombia (FARC), in which an estimated 260,000 people died and which displaced more than five million civilians, a revised peace agreement was signed in November 2016 (BBC 2016). Other armed rebel groups are still active, and the post-conflict era brings new challenges.

Institutions. Colombia has a comprehensive institutional set up for climate change policy that has been consistently strengthened over the last years and combines both top-down and bottom-up elements. Climate change discourse is embedded in larger economic and social debates and policy.

1.2 Emission trends

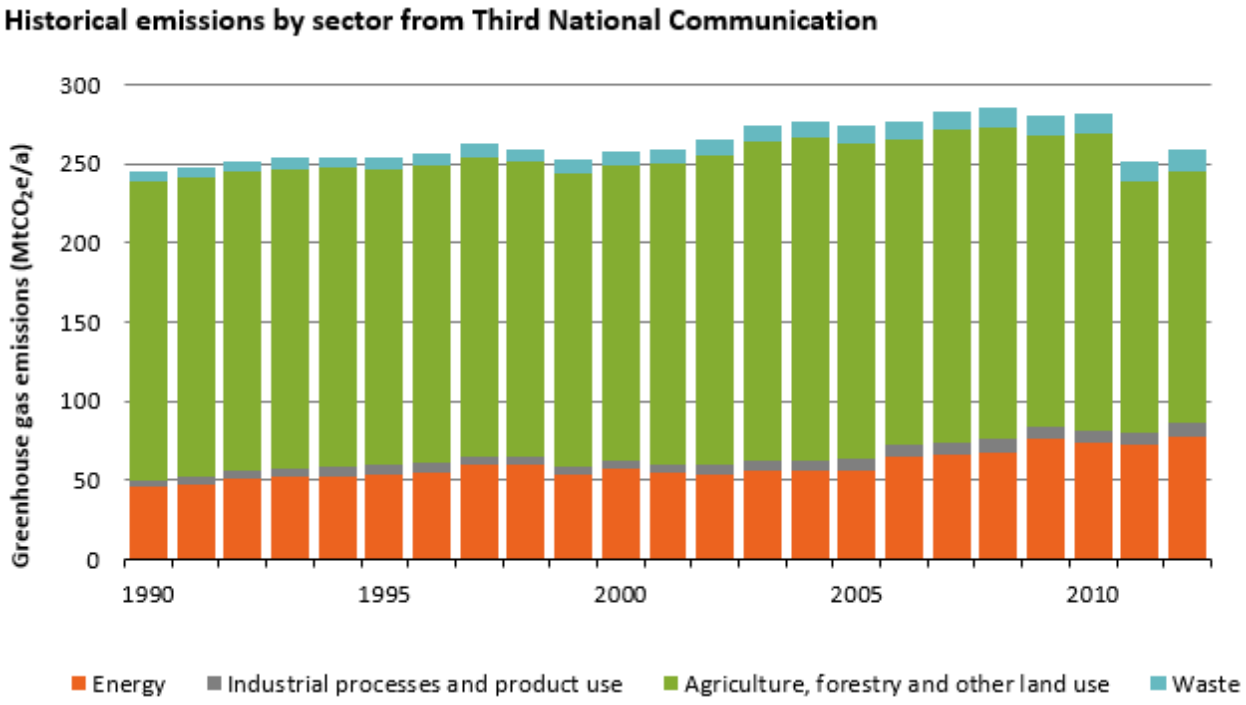
Emissions. Colombia's emissions slightly increased from 1990 to 2008, remained almost constant from 2008 to 2010 and then decreased by 8% from 2010 to 2012, the last year for which inventory data is available (see Figure 1). This is mainly due to significant reduction of emissions from deforestation, although at the same time the methodology behind the calculation of those reductions has also changed and therefore it is not entirely clear if the emissions from deforestation reflect actual emissions reductions.

Historically, the biggest contributor to Greenhouse Gas (GHG) emissions was the LULUCF sector. Total emissions without LULUCF rose from 120 $MtCO_2e$ in 1990 to 167 $MtCO_2e$ in 2012. According to Colombia's Third National Communication that was released in September 2017, emissions from LULUCF accounted for 55% of economy-wide emissions in 2012, down from 90% in 2000.

Emissions inventory data published in the Third National Communication show significant differences compared to earlier published inventory data, including from the First Biennial Update Report (BUR) published in 2015 and data included in the country's Intended Nationally Determined Contribution (INDC).

These differences are mainly due to a change in methodology. While both inventories are based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC guidelines), the BUR used tier 1 and 2 guidelines while the Third National Communication is based on tier 2 and 3 guidelines, which include also local emission factors. As a result, emissions in 2010, which is used as base year in Colombia's INDC, are much higher in the Third National Communication than in the BUR (281 $MtCO_2e$ compared to 224 $MtCO_2e$) (IDEAM 2017c; IDEAM et al., 2015).

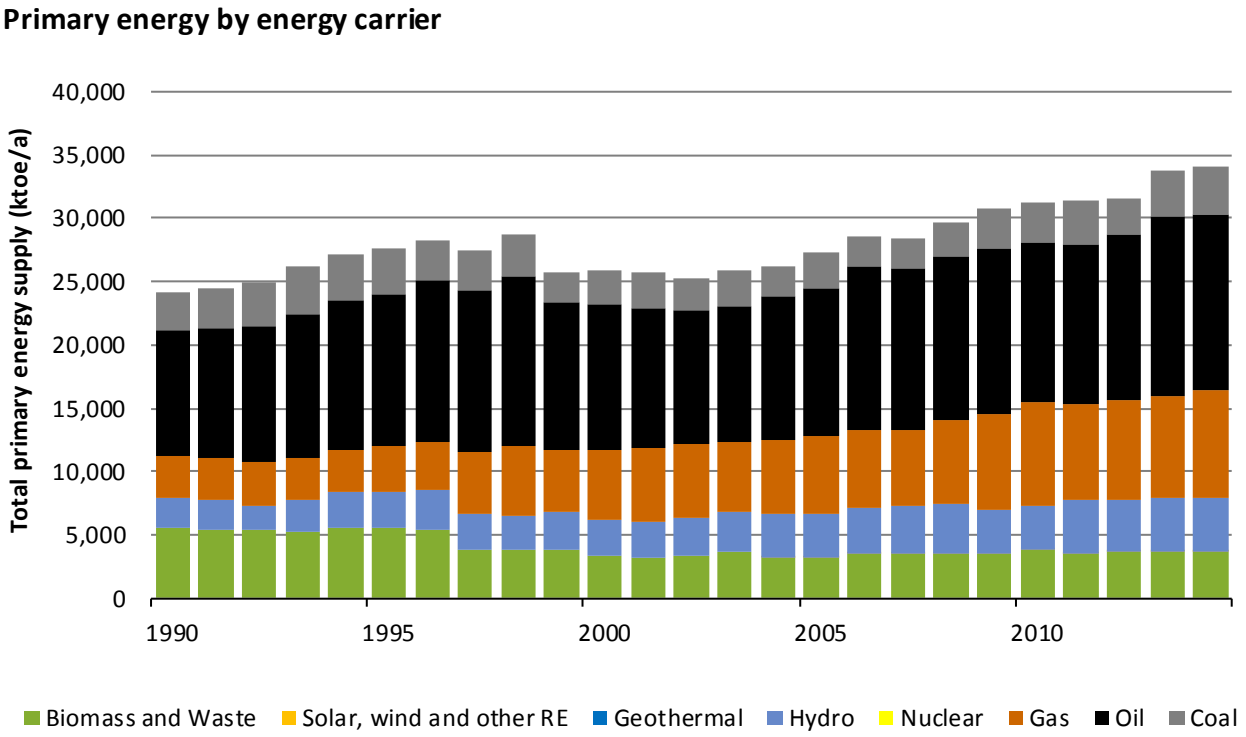
Figure 1: Colombia's emission profile based on its Third National Communication 2017



Data source: Colombia's Third National Communication (includes only gross emissions from AFOLU), IDEAM (2017c)

Energy system. Colombia is an energy rich country, in particular with regards to coal, gas and hydropower. In 2014, it exported more energy (coal) than it consumed domestically. The energy mix is slowly changing over time. Especially gas has risen in importance (Figure 2).

Figure 2: Colombia's historical energy profile



Data sources: IEA (2016a)

Colombia's electricity consumption has almost doubled over the last decade, with an annual growth rate of around three to four percent reaching 62 TWh in 2014 (IEA 2017). Electricity is mainly generated by hydropower (71% in 2014; IEA 2016e). However, coal-fired electricity capacity has been the fastest-growing technology in Colombia's electricity mix, from 6.3% in 2010 to 8% in 2016.

To cope with the expected future growth in energy demand, decrease its dependence on hydropower (due to increasing and more severe droughts in the past) and boost exports, Colombia is concentrating on expanding its coal and gas fired electricity capacity. At the same time the government plans to increase the share of grid-connected renewable capacity (other than hydropower, but including biomass) from 3.3 to 6.5% by 2020 (Briscoe et al. 2016).

Coal. Colombia is the eleventh largest coal producer in the world, with a production of around 90 Mt per year. The export share is around 95%, which makes Colombia the fourth largest coal exporter in the world (IEA 2016d;Garcia et al. 2017). Colombia is estimated to have 5.041 Gt of probable coal reserves (IEA 2015). The export value amounted to USD 5.3 billion, and coal is responsible for 14% of the country's export earnings (MIT 2017). Thus, the coal industry is a key economic factor for the whole country, providing jobs and royalties for coal mining regions.

The majority of coal is exported to Europe (Colombia is Germany's second largest supplier of coal after Russia) and North America due to its low production cost and high-quality. Colombia's coal export earnings have been decreasing since 2015 due to a drop in international coal demand especially from its main export partners. Lower revenue production ratios pose a threat to the profitability of the sector. Coal is therefore increasingly being directed towards domestic use underpinning the plan to ramp up coal fired power plants. By July 2017, an additional 550 MW in coal fired power capacity had been announced and 250 MW are under construction (Global Coal Plant Tracker 2017).

1.3 INDC and ongoing activities

Climate change strategy	✓
Green growth strategy	(✓)
Energy strategy aligned with CC/GG strategy	(✓)
Institutional coordination on climate change	✓
Renewable energy targets	✓
Level of NDC ambition (CAT rating)	n.a.
Reliance on coal (current)	high
Expected reliance on coal (2030)	high

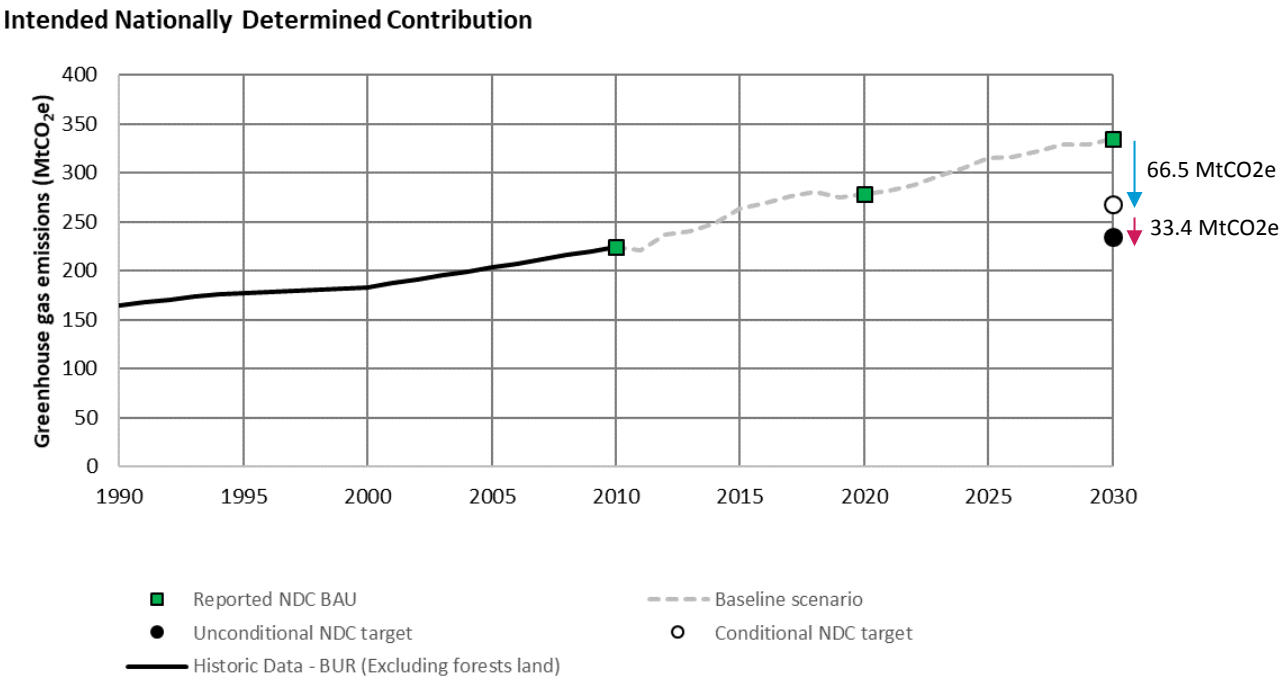
Following the successful adoption of the Paris Agreement, Colombia signed the treaty in April 2016, and initiated the internal process for the subsequent ratification of the same. Congress passed the Agreement in June 2017, but the ratification process still requires additional steps, including a review by the Constitutional Court (IDEAM 2017c).

Colombia's INDC contains an unconditional economy-wide reduction pledge of 20% versus a business-as-usual (BAU) scenario in 2030, as well as up to 30% below BAU in 2030, conditional to sufficient international support (Gobierno de Colombia 2015). The INDC is not broken down into sector specific targets (Gobierno de Colombia 2015).

It is important to look at the respective differences in emissions from 2010 to 2012, as this could have an impact on Colombia's emissions trajectory. The BAU emissions scenario for the INDC was projected with a base year of 2010, based on the GHG inventory published under the first BUR in 2015. Under this scenario, emissions were expected to rise to around 237 $MtCO_2e$ in 2012. However, according to the GHG inventory in the BUR, emissions actually decreased between 2010 and 2012, due in part to a significant reduction in LULUCF emissions. The GHG Inventory published under the Third National Communication in 2017 shows the same decreasing trend between 2010 and 2012, but reports a higher value for total emissions in 2012 than the BUR due to a methodology change. If emissions follow a linear trend based on the decrease from 2010 to 2012 reported in the Third National Communication, it is likely that Colombia will more easily achieve its INDC targets. Nevertheless, the country's expansion in coal-fired capacity might yet compromise its climate mitigation efforts.

It is still unclear whether changes to the BAU projections (which, the INDC stated, were to be confirmed) will be made when the final NDC will be submitted to the UNFCCC.

Figure 3: Colombia's projected emissions and INDC target



Data source: IDEAM (2015)

Colombia has developed a very comprehensive policy framework for its climate change policy across different levels of government (national, regional, municipal). In 2011, the National Council for Social and Economic Policy (El Consejo Nacional de Política Económica y Social – CONPES) issued CONPES 3700 on Climate Change, which outlines the institutional strategy for the articulation of policies and actions on the issue of climate change.

Building on CONPES 3700, several plans, strategies and activities emanated. One of the most important is Colombia's Low Carbon Development Strategy (ECDBC) passed/adopted in 2011. ECDBC is a long-term strategy (up to 2040) aimed at decoupling GHG emissions from economic growth. The ECDBC is now in its third stage, focusing on the identification and implementation of prioritised sectoral mitigation actions to implement the INDC target (IDEAM 2017c). To this end, it was decided to allocate emissions and mitigation measures to the different ministries instead of allocating them to different IPCC sectors. This decision was taken because of a perceived need to assign clear responsibilities to different entities and track progress.

To date, the different line ministries have identified 33 prioritised mitigation measures which, if successfully implemented, would mean that Colombia would overachieve its unconditional INDC pledge.

1.4 Mitigation potential beyond the INDC

The INDC lists the country's total GHG emissions in 2010 as 224 $MtCO_2e$, out of which 130 $MtCO_2e$ were from AFOLU, 71 $MtCO_2e$ from energy, 14 $MtCO_2e$ from waste and 9 $MtCO_2e$ from industrial processes (Gobierno de Colombia 2015).

The overall anticipated mitigation potential from the prioritised mitigation measures would reduce emissions by 75.75 $MtCO_2e$ or 22.3% compared to BAU emissions in 2030. The highest expected absolute emission reductions are from deforestation (-34 $MtCO_2e$) and agriculture (-16 $MtCO_2e$) (IDEAM 2017c).

Emission reduction potentials that would go beyond measures considered in the INDC can be found in the agriculture, forestry, housing and energy sectors. Working with the private sector towards a more sustainable supply chain, especially within the country's milk cluster, could achieve additional emissions reductions in the range of 6.3 to 18.5 $MtCO_2e$ by 2030 (authors calculations, based on Gerber et al. 2013).

In the forestry sector, mainstreaming forest conservation efforts in existing illicit crop substitution programmes is estimated to offer an emission reduction potential of around 25.1 $MtCO_2e$ or 53,579 hectares by 2030 (authors calculations, based on inventory data from the Third National Communication), most of which would be additional to the INDC. At the same time, keeping deforestation under control is a key factor for Colombia to meet its INDC target.

Another promising mitigation potential which has additional positive co-benefits for vulnerable parts of the population can be achieved if the Green Building Code, adopted in 2015, is made mandatory for the social housing segment. In addition to avoiding the lock-in of emissions in the future, emissions could be reduced by 25 $ktCO_2e$/ y per housing unit (based on research carried out in the framework of similar UBA/DEHSt project, *FKZ* 3715 42 506 0).

Lastly, the mitigation potential from increasing renewables in the national grid is estimated at around 38 $MtCO_2e$ by 2030 Universidad de los Andes (2016). Currently, large scale solar PV and wind are practically not existent in the energy mix. Measures to tap into that potential could include the integration of demand side variables in the regulatory framework and/ or the integration of co-benefits related to increased renewable energy use to create a level playing field for wind and solar PV.

2 Part II: Full country analysis

2.1 Country background

Geography. Colombia, South America's fourth largest country, covers an area of 1.1 million km^2. The country consists of five natural regions (Andes mountain range, Pacific Ocean, Caribbean Sea, Amazon rainforest and the so-called *Llanos* (Orinoquia – Colombia's plains shared with Venezuela). It borders Panama in the north-west, Venezuela and Brazil in the east and Ecuador and Peru in the south (Cancilleria 2017). It is the only South American country that has direct access to both the Caribbean Sea and the Pacific Ocean.

Figure 4: Map of Colombia

Source: Google Maps

Population. With a population of 48.7 million in 2016 (World Bank 2017), Colombia is the 28th most populated country in the world and the second-most populated in South America. The growth rate of its population is slowly declining and has reached 0.9% in 2016. Projections of the Population Division

of the United Nations Department of Economic and Social Affairs (UN DESA) indicate that the country's population will grow to 53 million in 2030 and 54.7 million in 2050 (UN 2017). Colombia's population is mostly concentrated in the metropolitan area of Bogotá (9.8 million inhabitants in 2015), along the Caribbean coast and the Andean high-lands. The east and south are very sparsely populated (World Population Review 2017). 76% of the population lives in urban centres (2012) (United Nations, Department of Economic and Social Affairs 2014). Colombia also has one of the highest number of internally displaced people (IDP) in the world (IDMC 2017) which is projected to decrease following the peace agreement reached with the Revolutionary Armed Forces of Colombia (FARC) in November 2016.

Economy. Colombia is an upper middle-income economy and has seen economic growth rates of, on average, 4-6% between the early 1990s and 2007. In 2008/09 the country was affected by the global economic downturn and growth slowed down significantly, reaching 1.7% in 2009. After a strong resurge in the early 2010s, helped by a commodity boom, the country suffered from high inflation (reaching 5.75% in 2016) and a sharp decrease in international oil prices. During the commodity boom, oil exports accounted for half of Colombia's exports and a fifth of government revenues. To ease the downturn, Colombia depreciated its currency, the Colombian peso, by around 80% between mid-2014 and early 2016. GDP growth stood at 1.7% in 2016 and is estimated to reach 3.3% in 2018 (World Bank 2017).

Table 1: Key socio-economic figures

Indicator	Colombia	% change since 1990	World	Germany	Year
Population [million]	48.7	+42%	7442	82.7	2016
GDP [2016 billion USD]	282.5	+601%	75,641,577	3,467	2016
GDP/Cap [2016 USD/cap]	6,300	+436%	10093	41,313	2016
HDI [0 – 1]	0.727	+23.2%	n.a	0.92	2014
Electrification rate [%]	97	+5.4%	84.6	100	2012
GINI index [0 – 100]	6.32	+418%	n.a	n.a	2016
Corruption index [1 – 6]	3	+20%[1]	2.88	n.a.	2015
Urbanization [% of total]	76	+12%	53.9	75.3	2015

Data sources: UNDP (2016); United Nations (2014); ND-GAIN (2017); World Bank (2017), GDP per capita calculated based on World Bank (2017)

Average nominal GDP per capita is moderately high at about USD 6,300 (2016), down from 7,900 in 2014. Not everyone was lifted out of poverty by Colombia's growth rates over the last decades and wealth is unevenly distributed. At the same time, Colombia's poverty rate continues to fall. In 2000,

[1] Please note that the percentage change is calculated based on 2005 data as no earlier data is available.

16.2% of the population was living on less than USD 1.90 a day compared to 5.7% in 2016. However, when using the national poverty standard, this figure rises to 27.8% (Ibid).

The country ranks 2nd in Latin America, after Peru, for its ease of doing business (World Bank 2017). Colombia's main economic sectors are agriculture (palm oil, coffee, tobacco among others), mining (including coal and oil extraction), textile, food processing, chemicals and other industrial products (Indexmundi 2017).

Political system. Colombia is a stable presidential representative democratic republic, with a directly-elected president as head of state (currently Juan Manuel Santos serving a second mandate). The president appoints a council of ministers as the executive. Colombia has currently 16 ministries. The legislature is formed by the Congress, a bicameral institution composed of a Senate (102 senators) and a Chamber of Representatives (166 representatives). Senators are elected nationally and Representatives of the Chamber in electoral districts for a four-year term. The next general presidential election is scheduled to take place in May 2018 (Auswaertiges Amt 2017).

Although the country is pushing towards more decentralisation, Colombia has historically been a largely centralised country, organised in 32 provinces in addition to Bogota as capital district. Provinces are mainly responsible for economic and social development of their territories, including some environmental issues (Ibid).

Economic and political interests often mingle. Political experts have claimed that Colombia is subject to clientelism and vested interests of powerful economic stakeholders such as the coal and mining industries. Relatedly, Colombia's corruption levels remain high, legal enforcement is often weak and inequality is a persistent challenge (Briscoe et al. 2016).

Armed conflict and post-conflict era. Following an over 50-year conflict with the Revolutionary Armed Forces of Colombia (FARC), in which an estimated 260,000 people died and which displaced more than eight million civilians, a revised peace agreement was signed in November 2016 (BBC 2016). One month earlier, President Santos was awarded the Nobel Peace Prize for his efforts to end the conflict.

The Government of Colombia and FARC are advancing on the implementation of the peace agreements. Major achieved milestones are the demobilisation of FARC members to 26 designated zones, the disarmament of the rebel group accompanied by a UN mission and the creation of FARC's own political party (Alternative Revolutionary Force for the Common People - keeping thus the same acronym, FARC). Additionally, in February formal peace talks started with the National Liberation Army (ELN), another rebel group operating in Colombia.

However, Colombia´s challenges go beyond these two groups; further issues include illegal crops, criminal groups and corruption. In fact, the early post-conflict era sees rising deforestation as other groups move into areas that were formerly held by the FARC, taking advantage of the power vacuum left behind. Illegal logging and mining as well as cattle ranching is on the rise, and deforestation has increased by over 44% from 2016-17 (The Guardian 2017).

Position in the international climate negotiations. Colombia is one of the most vocal countries in the climate negotiations under the UNFCCC, having shown leadership on multiple occasions. Together with Costa Rica, it is informally leading the Independent Association of Latin America and the Caribbean (AILAC), a group which sees itself as bridging the North-South divide and a 'revolt from the middle'. AILAC also consistently pushed all countries to step up their climate commitments under the UNFCCC negotiations (Friedman 2013).

In addition, Colombia is part of the G77 (the largest country grouping of developing countries) and the Cartagena group (formed at COP15 in Copenhagen, a proactive and progressive group advocating an ambitious, comprehensive and legally-binding international agreement).

Bilateral Cooperation with Germany. Colombia is an important partner country in South America for the German government, with increasingly strong ties (Auswaertiges Amt 2017). The priorities for cooperation are a) the peace process and prevention of crisis b) environment and c) sustainable economic development. Germany is Colombia's most important commercial partner in the EU with an annual trade volume of EUR 3.2 billion (2015) (Ibid). In 2015, Germany imported Colombian coal briquettes worth USD 256 billion (MIT 2017). Germany gets the Colombian coal through the Netherlands which exports 73% of Colombian coal to other countries, mostly Germany (87%) (Garcia et al. 2017).

Colombia's First Biennial Update Report (BUR), submitted in 2015, lists 21 German-funded climate activities for the period 2010-14, with a disbursal of ca. USD 40 million (EUR 33.8 million). In addition, Germany funds six more projects through the NAMA facility (one project) or in cooperation with other countries and/ or the European Union. Activities include mitigation projects in the transport sector (e.g. the transport-oriented development - TOD NAMA), forestry and REDD+ (e.g. reducing deforestation in the Amazonas) and adaptation projects to prevent coastal erosion (IDEAM 2015).

Colombia is also a member of the NDC Partnership that was founded by Germany as a platform for effective NDC implementation. The NDC cluster lists three core NDC implementation activities funded through the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). IKI supports Colombia for example with the preparation of a roadmap to develop a climate change strategy for 2050.

Emissions. Colombia's emissions slightly increased from 1990 to 2008, remained almost constant from 2008 to 2010 and then decreased by 8% from 2010 to 2012, the last year for which inventory data is available. Historically, the biggest contributor to GHG emissions was the LULUCF sector. Total emissions without LULUCF rose from 120 $MtCO_2e$ in 1990 to 167 $MtCO_2e$ in 2012. According to Colombia's Third National Communication that was released in September 2017, emissions from LULUCF accounted for 55% of economy-wide emissions in 2012, down from 90% in 2000[2].

Relative emissions have decreased significantly from 1990 to 2012. Per capita emissions dropped by 23% over that period, reaching 5.5 tCO_2e/cap in 2012, the emissions intensity by 89% and the energy intensity by 85% (Figure 5, Table 3). Most of this is due to a large drop in calculated AFOLU emissions which were revised based on the application of a new methodology.

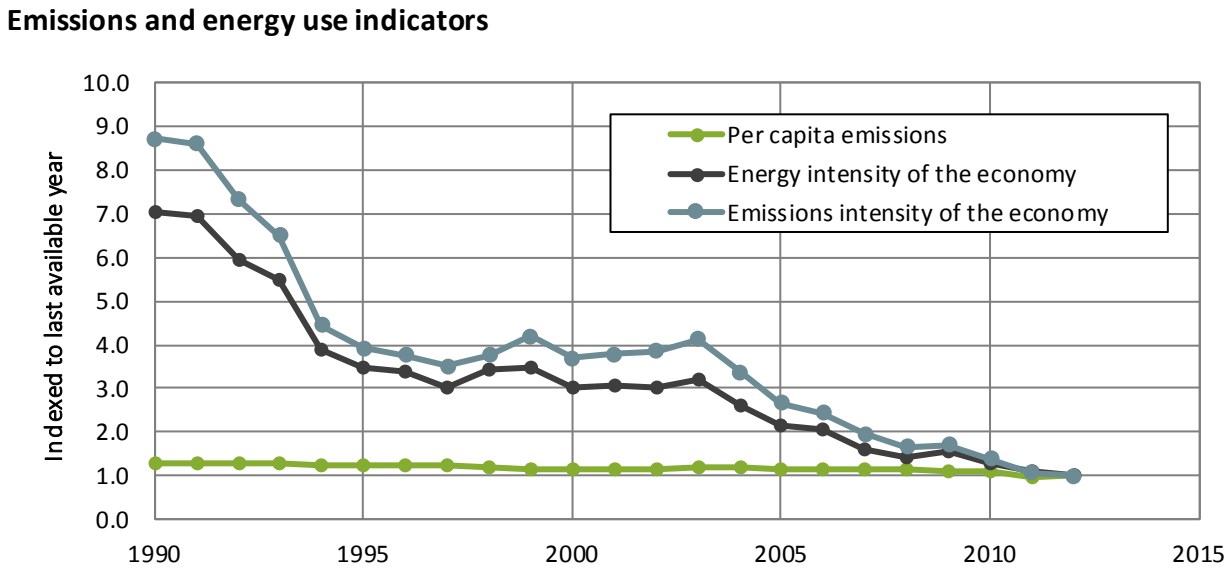
[2] Emissions inventory data published in the Third National Communication show significant differences compared to earlier published inventory data, including from the First Biennial Update Report (BUR) published in 2015 and data included in the country's Intended Nationally Determined Contribution (INDC). These differences are mainly due to a change in methodology. While both inventories are based on IPCC guidelines from 2006, the BUR used tier 1 and 2 guidelines while the Third National Communication is based on tier 2 and 3 guidelines, which include also local emission factors. As a result, emissions in 2010, which is used as base year in Colombia's INDC, are much higher in the Third National Communication when compared to the BUR (281 $MtCO_2e$ compared to 224 $MtCO_2e$) (IDEAM 2017c; IDEAM et al., 2015).

Table 2: 2012 emissions data from Colombia's Third National Communication

Sector	Value	Unit	Share in 2012
Total (excluding LULUCF)	166.62	$MtCO_2e$	100%
Energy industries	78.02	$MtCO_2e$	47%
Manufacturing industries	8.87	$MtCO_2e$	5%
Agriculture	68.22	$MtCO_2e$	41%
Waste	13.31	$MtCO_2e$	8%
LULUCF	92.3	$MtCO_2e$	
Total emissions (including LULUCF)	258.97	$MtCO_2e$	

Data source: National GHG inventory 2012, IDEAM (2017c)

Figure 5: Relative emissions indicators



Data sources: Colombia's Third National Communication (includes only gross emissions from AFOLU), IDEAM (2017c); IEA (2016b); Gütschow et al. (2016); World Bank (2017); ND-GAIN (2017)

Table 3: Key emissions, energy and environmental data

Indicator	Colombia	% change since 1990	World	Germany	Year
GHG/cap [tCO_2e/cap]	5.5	-23%	6.49	11.74	2012
GHG/GDP [tCO_2e/mln 2017 USD]	700	-89%	615.95	266.37	2012
Energy/GDP [ktoe/mln 2017 USD]	0.09	-85%	0.179	0.09	2012
Global share of emissions [%]	0.32	-29.5%	n.a.	1.76	2012
Air pollution index (P2.5)	17.6	-15.4%	42.27	13.7	2015
Vulnerability index [0 – 1]	0.366	-11.2%[3]	n.a.	0.226	2015

Data sources: IEA (2016b); Gütschow et al.(2016); World Bank (2017); ND-GAIN (2017)

Energy system. Primary energy demand in 2014 was mainly met by the use of oil (38%), gas (25%), hydropower (11%), biomass/ waste (10%) and coal (16 %) (UPME 2017).

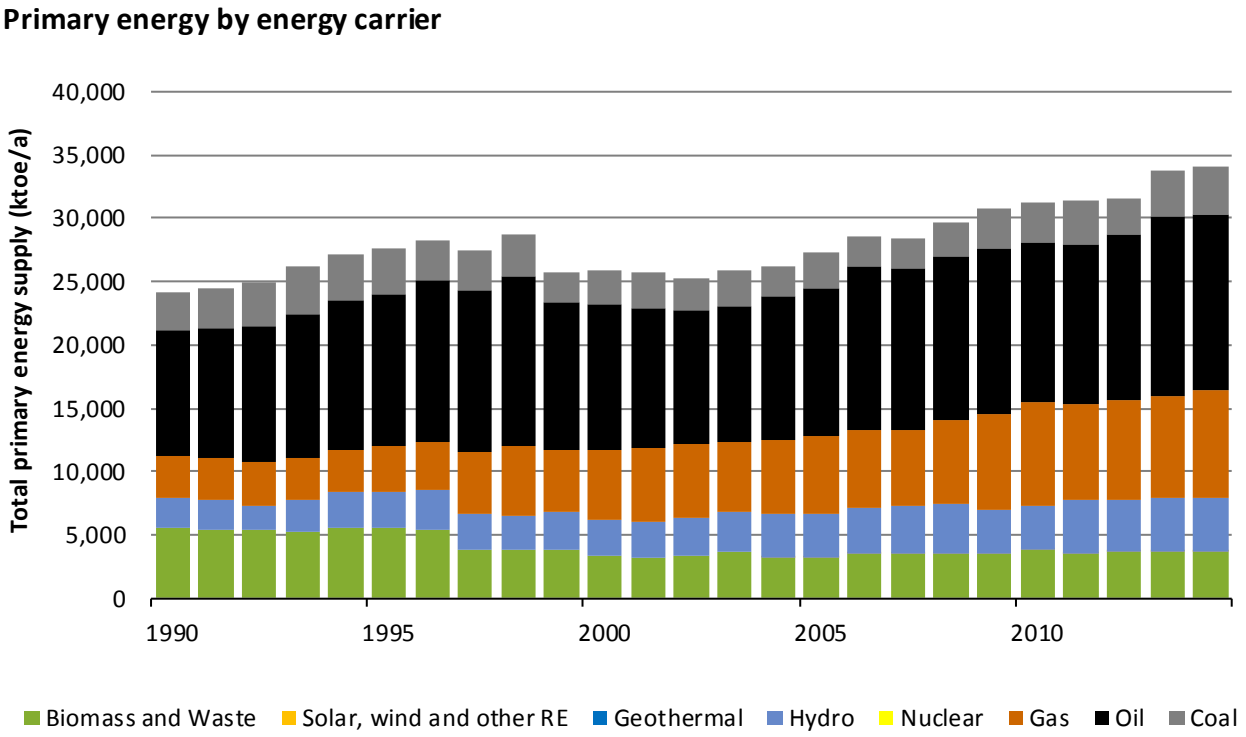
Colombia is an energy rich country, in particular with regards to coal, gas and hydropower. It exports more energy (coal, out of which around 95% is exported) than it consumes domestically. The energy mix is slowly changing over time. Gas has especially risen in importance. This might change as Colombia's gas reserves are decreasing. The proven gas reserves, although slightly increasing, amount to 162.2 billion cubic metres (in comparison, the production stood at 11.8 billion cubic metres of gas in 2014) (World Energy Council 2018).

Colombia's electricity consumption has almost doubled over the last decade, with an annual growth rate of around three to four percent, reaching 62 TWh in 2014 (IEA 2017). Demand growth is largely linked to the country's economic growth and greater public spending on power and urbanisation (Briscoe et al. 2016). The Colombian electricity sector has an emission factor of 374 gCO_2/kWh which is low compared to other countries and depends on the large share of hydro power to produce electricity (around 70%) (Ministerio de Minas y Energía 2014). The global average emission factor for electricity generation is around 500 gCO_2/kWh (World Bank 2014). Coal-fired electricity capacity has been the fastest-growing technology in Colombia's electricity mix, from 6.3% in 2010 to 8% in 2016.

In recent years, the country's electrification rate has increased from 89.9% in 2009 to 97.8% in 2014 (World Bank 2017). To cope with the expected future demand growth, to diversify electricity production from the dominating hydropower and to boost exports, Colombia is mainly concentrating on expanding its coal and gas fired electricity capacity. At the same time, the government plans to double the share of grid-connected renewable capacity (other than hydropower) from 3.4% to 6.5% by 2020 (Briscoe et al. 2016).

[3] Please note that the percentage change is calculated based on 1995 data due to unavailability of earlier data.

Figure 6: Colombia's historical energy profile



Data sources: IEA (2016a)

Table 4: 2014 total primary energy supply by energy carrier

Fuel	Value	Unit	Share in 2014
Biomass and waste	3,855	ktoe	10%
Solar, wind and other RE	15	ktoe	0%
Geothermal	0	ktoe	0%
Hydro	4,320	ktoe	11%
Nuclear	0	ktoe	0%
Gas	9,777	ktoe	25%
Oil	14,468	ktoe	38%
Coal	6,033	ktoe	16%

Data source: UPME (2017)

2.2 Institutional set up

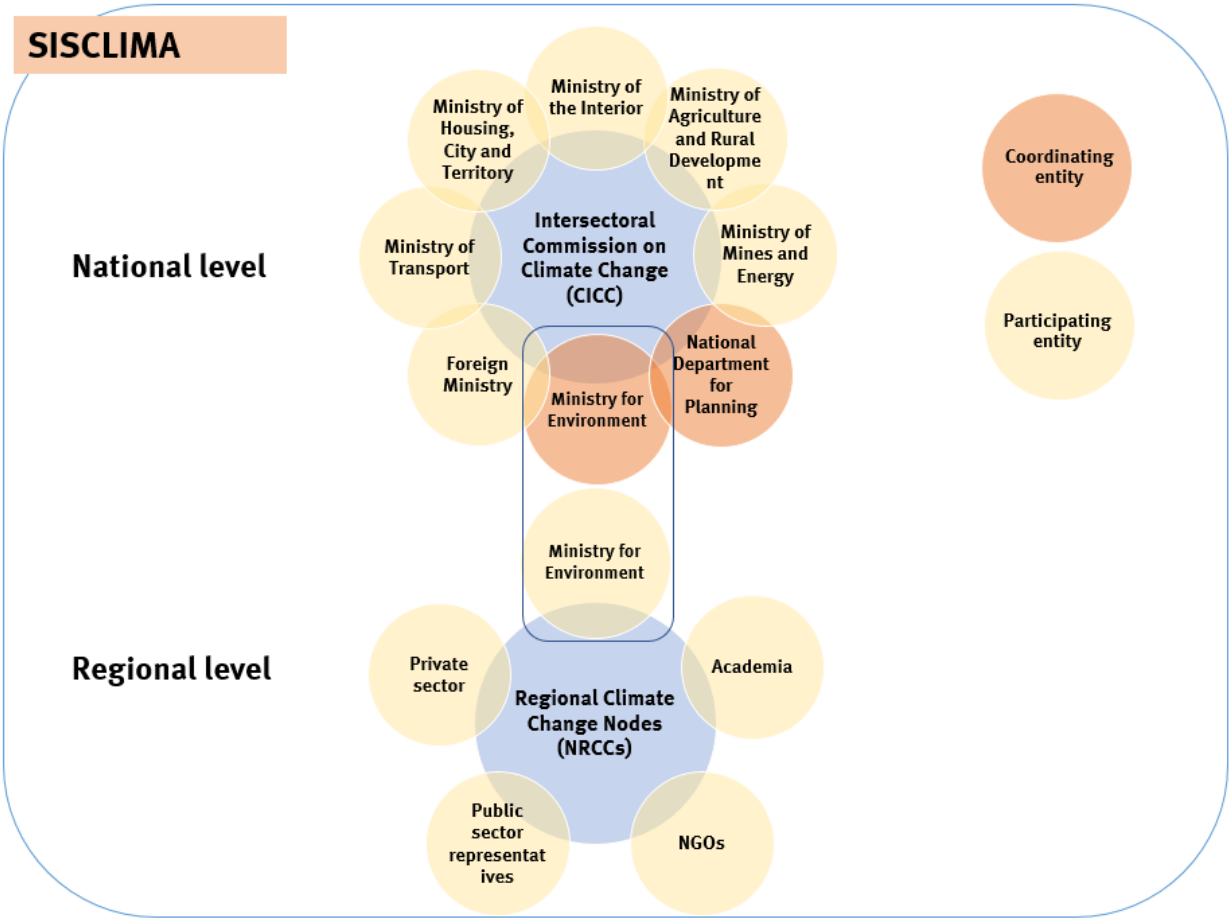
Colombia has a comprehensive institutional set up that has been consistently strengthened over the last years and combines both top-down and bottom-up elements. Climate change is regarded as inextricably linked to economic and social issues. Therefore, recent climate policy has been defined by the National Economic and Social Policy Council (CONPES) whose secretariat is led by the National Planning Department (DNP) and which receives directions directly from the President. Colombia's

executive plays the most important role in the field of climate change in the country and President Santos is committed to reducing GHG emissions and preserving biodiversity.

The institutional set up to manage climate change was overhauled in 2011 when CONPES and DNP, as executive secretariat to CONPES, were put in charge of the country's response to climate change, together with the Ministry for Environment and Sustainable Development (MADS).

In 2016, CONPES established the National Climate Change System (SISCLIMA) in charge of coordinating and promoting climate change action and policy (decree 298/2016). SISCLIMA establishes authorities for inter-sector coordination at the national level (*Comisión Intersectorial de Cambio Climático* - CICC) and, as a new push for more involvement of the regions in the formulation and implementation of climate change strategies, defines the Regional Climate Change Nodes (*Nodos Regionales de Cambio Climático*, NRCCs), to create an integrated system for mitigation and adaptation. Private and relevant academic stakeholders have also been engaged and invited to join the NRCCs (Forest Carbon Partnership Facility 2017). MADS participates in the meetings of the NRCCs thereby contributing to coherence between sectoral and regional climate change policies and INDC implementation.

Figure 7: Flowchart of organisational set-up (SISCLIMA)



Source: Authors

A number of different ministries and government departments play key roles in Colombia's approach to climate change, in particular MADS and the DNP. MADS and DNP are responsible for heading the newly founded CICC which was also established through decree 298/2016. The CICC convenes the Ministry of Interior, Ministry of Agriculture, Ministry of Energy, Ministry of Transport, Ministry of

Foreign Affairs and the Ministry of Housing or their delegates (Ministerio de Ambiente y Desarrollo Sostenible 2016). In 2017, the CICC approved the Climate Change National Policy that integrates the mitigation and adaptation strategies and mainstream climate change into territorial and sectoral planning processes.

Colombia's National Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) developed the new climate change scenarios (2015) as well as the new emissions estimates for national and subnational emissions inventories.

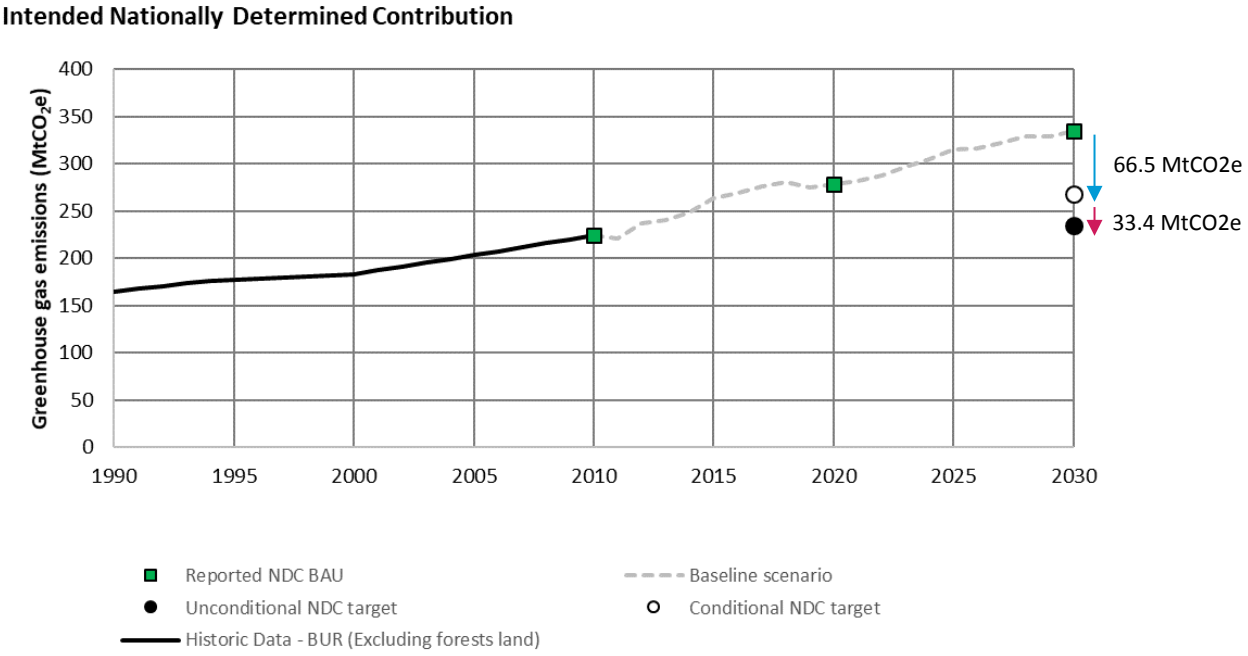
2.3 Description and evaluation of the INDC

In 2009, Colombia made its first international climate pledge, consisting of a series of mitigation actions (WRI 2015). During the preparations for the INDC which started in 2012 which included an extensive stakeholder process, Colombia's government closely worked with the University of the Andes. Based on detailed consultations with different ministries and other stakeholders, the university prepared an extensive study on mitigation potentials in the country. The study and collective agreements formed the basis for developing the BAU and mitigation scenarios, which resulted in the national emission reduction target (Gobierno de Colombia 2015).

Colombia's INDC contains an unconditional economy-wide domestic reduction pledge of 20% versus a business-as-usual (BAU) scenario in 2030, as well as up to 30% below BAU in 2030 conditional on sufficient international support (Figure 8). The INDC is not broken down into sector specific targets.

When comparing the current level of mitigation action with the goal of limiting temperature increase to 2°C as set out in the Paris Agreement ("effort sharing"), research shows that Colombia's unconditional emission reduction target is aligned or slightly below what would be characterised as fair effort (Höhne et al. 2014).

Figure 8: Colombia's projected emissions and INDC target



Data source: IDEAM (2015)

The INDC lists the country's total GHG emissions in 2010 as 224 $MtCO_2e$, out of which 130 $MtCO_2e$ are from AFOLU, 71 $MtCO_2e$ from energy, 14 $MtCO_2e$ from waste and 9 $MtCO_2e$ from industrial processes. Under the BAU scenario, emissions are projected to increase to 278 $MtCO_2e$ in 2020 and 335 $MtCO_2e$ in

2030. Under an INDC compatible scenario, emissions are estimated to reach 268 $MtCO_2e$ in 2030, with per capita emissions of 4.6 tCO_2e (instead of 5.8 in the BAU scenario) (Gobierno de Colombia 2015). It is not clear whether these projections will be revised to reflect more recent inventory data included in the Third National Communication, as Colombia has not yet ratified the Paris Agreement and thus not yet submitted the final NDC to the UNFCCC.

When comparing historical data for 2010 included in the INDC to historical data for 2010 in the Third National Communication, total GHG emissions in 2010 rise to 281 $MtCO_2e$, out of which 187.4 $MtCO_2e$ are from AFOLU (including only gross emissions), 73.63 $MtCO_2e$ from energy, 13.12 $MtCO_2e$ from waste and 7.57 $MtCO_2e$ from industrial processes (IDEAM 2017c).

It is important to look at the differences in emissions between 2010 and 2012, as this could have an impact on Colombia's emissions trajectory. The BAU emissions scenario for the INDC was projected with a base year of 2010, based on the GHG inventory published under the first BUR. Under this scenario, emissions were expected to rise to around 237 $MtCO_2e$ in 2012. However, according to the BUR inventory, emissions actually decreased between 2010 and 2012, due, in part, to a significant reported reduction in LULUCF emissions. This drop in emissions is however due in part also to a change in methodology and thus has to be considered with caution. The Third National Communication inventory shows the same decreasing trend between 2010 and 2012, but reports a higher value for total emissions in 2012 than the BUR due to a methodology change. If emissions follow a linear trend based on the decrease from 2010 to 2012 reported in the Third National Communication, it is likely that Colombia will more easily achieve its INDC targets.

Another reason why Colombia could more easily achieve its INDC is due to the fact that BAU emissions included in the INDC are based on an estimation of future economic growth of 5% annually (IDEAM et al., 2015). However, in the short term, due to a shock in international oil prices, GDP is likely to grow considerably less, with growth likely to be well below 3%.

Nonetheless, some challenges persist. For example, it will be important to control emissions from deforestation. While emissions from deforestation have reportedly decreased from 2010-2012, it is expected that deforestation will again lead to increasing emissions because of an increase in the cultivation of illicit crops, following a return of ex rebels and other parts of the population to their lands after the peace agreement with the FARC (Minambiente 2015).

In addition, Colombia's planned expansion of coal fired capacity is another major challenge. It is unclear how the country will be able to meet its emission reduction objectives when an additional capacity of 250 MW is already under construction and another 550 MW have been announced (also see chapter 2.8 on coal) (Global Coal Plant Tracker 2017).

Colombia explicitly refers to the role of mitigation (and adaptation) in its peace process. The INDC here underlines the potential of mitigation and adaptation to facilitate the consolidation of peace in territories where productive activities and land uses can play a key role in providing better development opportunities, in particular in rural communities (Gobierno de Colombia 2015).

In conclusion, three key findings on Colombia's BAU scenario and INDC are important:

- The INDC is based on a thorough analysis of mitigation potentials and following an extensive and inclusive stakeholder process
- The unconditional and possibly the conditional INDC is likely to be met with current policies, if possible changes to BAU projections, based on revised emissions inventory data and likely lower economic growth are considered, and if deforestation is being controlled
- However, Colombia's planned expansion of coal fired capacities could yet compromise this achievement

2.4 National MRV arrangements

The Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) is in charge of preparing national communications and submissions to the UNFCCC, in collaboration with other ministries and agencies

Colombia has submitted three national communications and one Biennial Update Report to the UNFCCC. Its first national communication was submitted to the UNFCCC in 2001, the second one in 2010 and the third one in September 2017 (UNFCCC 2017b). The first Biennial Update Report was submitted in 2015, and initial REDD+ forest reference emissions levels (FRELs) in 2014 which made Colombia one of the first six countries world-wide who submitted FRELs to the UNFCCC. However, the FREL submissions were focused exclusively on the Amazon Biome and thus are subnational and include only deforestation activities (UNFCCC 2017a).

The GHG emissions inventories published in Colombia's Third National Communication and first Biennial Update Report, which include complete emissions inventories for years up to 2012, are based on the 2006 IPCC guidelines. The Third National Communication has been verified by several international organisations, including the US Environmental Protection Agency and the FAO (Government of Colombia 2016). The Global Warming Potential (GWP) values used correspond to the Second Assessment Report of the IPCC (1995) for a 100-year period. One important difference between the Biennial Update Report and the Third National Communication is the tiers used for the emissions inventory. While the Biennial Update Report uses tier 1 and 2, the national communication is based on tier 2 and 3, which are region or country specific. This led to a revision of earlier published inventory data.

Colombia started developing a comprehensive national MRV system in 2013 with support from the World Resources Institute (WRI). Between 2013 and 2015, the country identified variables and indicators for its sectoral mitigation plans (PAS). A monitoring system for air pollution exists already (Transparency Partnership 2017a), and the identification of sectoral baselines and indicators for its industry, waste, transport, energy and agricultural sectors are under development (Ministry of Environment and Sustainable Development Colombia 2016). One challenge is that INDC implementation progress and tracking is now organised on a ministry by ministry level rather than at IPCC sector level (IDEAM 2017c). While this helps assign clear responsibilities for monitoring, it makes the reporting and verification of emissions more difficult given these have to be reported based on the IPCC sector categorisation.

A national registry to monitor emission reductions is still under development. According to recent plans this registry will be located in the country's environmental information system (SIAC) and would bring together standardised tracking for the implementation of policies and actions as well as individual efforts of regions and sectors and would be complemented by relevant impact and management indicators (Ministry of Environment and Sustainable Development Colombia 2016).

Currently, a voluntary corporate reporting programme is in place, based on the GHG Protocol. Emission reductions are monitored and reported under NAMAs, CDM, REDD+ and PDBC-PEMV[4]. In addition, guidelines have also been developed to identify financial resources, especially for governors, mayors, and project developers (Ministry of Environment and Sustainable Development Colombia 2016). The Colombian government has also announced that it will publish a methodological approach for monitoring forest degradation on a national scale by the end of 2017 (Forest Carbon Partnership Facility 2017).

[4] PDBC stands for Proyectos de Desarrollo Bajo en Carbono (low carbon development projects) and PEMV for Plan Estratégico de Monitoreo y Verificacion (strategic plan for monitoring and verification).

2.5 Climate change mitigation policies and strategies

National strategies. In 2011, the National Council for Social and Economic Policy issued CONPES 3700 on Climate Change, which outlines the institutional strategy for the articulation of policies and actions on the issue of climate change in Colombia. This document emphasises the importance of understanding climate change as a particular challenge to socio-economic development that requires the development of strategies at the sectoral as well as regional and national levels. It creates a framework for sectors and regions helping them to integrate adaptation and mitigation actions into their planning processes, make adequate use of resources, reduce their risk exposure and increase response capacity. It also creates a space for shared and coordinated management and information to allow for effective decision making of sectoral, regional or national actors (CONPES 2011).

Building on CONPES 3700, several plans, strategies and activities were developed. One of the most important is Colombia's 2011 Low Carbon Development Strategy (Estrategia Colombiana de Desarrollo Bajo en Carbono, ECDBC). ECDBC is a long-term strategy (up to 2040) aimed at decoupling GHG emissions from economic growth, implemented by MADS, with support from DNP and relevant line ministries. As such, the ECDBC is an important tool to deliver the objectives of the National Development Plan (CDKN 2016).

The ECDBC has three main components/ phases: 1) identification and assessment of alternatives and opportunities for low-carbon development; 2) design of plans, policies and measurements in low-carbon development (including NAMAs and the development of sectoral mitigation plans); and 3) implementation of the sectoral mitigation plans and NAMAs, regionalisation of climate activities and the construction of an MRV system (Ibid).

Between 2013 and 2014, under the lead of the Ministry of Environment, sectoral mitigation plans (Planes de Acción Sectorial – PAS) were formulated in eight areas (transport; energy; mining; hydrocarbons; industry; agriculture; housing, and waste and waste water). The PAS aim to maximise the carbon efficiency of economic activities at all levels while contributing to social and economic development. They collectively contain around 100 mitigation measures, based on an extensive study of the University of the Andes, but do not go into specific details about the measures or how those could be achieved (Universidad de los Andes 2016). Colombia's INDC is also largely based on this study.

Colombia is also formulating the REDD+ National Strategy (REDD+ NS) that forms part of the 2014–2018 National Development Plan (NDP). The REDD+ NS Strategy seeks to reduce deforestation and forest degradation in the country and positively impact the livelihoods and human well-being of indigenous peoples (Forest Carbon Partnership Facility 2017). Colombia started working on REDD+ in 2009, being active also in the UNFCCC REDD+ negotiations where it supports market-based mechanisms. In 2008, the country signed the "zero deforestation in the Amazon by 2020" initiative (Grantham Institute 2015).

Several initiatives are underway in the energy sector. The Programme for the Rational and Efficient Use of Energy and Other Non-Conventional Energy Forms (PROURE) aims at promoting the rational and efficient use of energy and alternative sources. PROURE also established a Fund for Clean Energy and Energy Efficiency (FENOGE) in 2014 to finance renewable energy projects. It is still under discussion how the Fund will operate and be set up (US AID 2016). In addition, the government has a target to increase the share of grid-connected renewable capacity (biomass, wind, solar) to 6.5% by 2020 (Briscoe et al. 2016).

Since 2014, Colombia has been preparing for OECD membership. As such, the country is also currently formulating its green growth strategy.

Colombia has voluntarily pledged USD 600,000 to the Green Climate Fund (GCF) (Green Climate Fund 2017). The country also created a national green growth fund, "Colombia Sostenible", aimed to support efforts to reconcile climate change mitigation and peace building in the country after the demobilisation of the FARC.

NAMAs and carbon finance. Three NAMAs are currently under implementation. They include one NAMA for domestic refrigeration aiming to reduce emissions from the domestic refrigeration sector by providing technical support and capacity building (NAMA Database 2017) and two NAMAs in the transport sector. The Colombia Transit Development (TOD) NAMA aims at better-planned, walkable, transit-oriented neighbourhoods to lower GHG emissions, reduce household transportation costs, expand access to jobs and services and improve social inclusion (Transparency Partnership 2017b). TOD is estimated to reduce emissions by 3.5 to 5.5 $MtCO_2e$ per year by 2040 (Briscoe et al. 2016). Another (unilateral) NAMA is looking at Sustainable Road Based Freight Transport and aims to accelerate the renovation of the cargo vehicle fleet with the aim to improve economic competitiveness and environmental performance of the freight transport sector (NAMA Database 2017; IDEAM 2017c).

The NAMA database lists another nine NAMAs under development, in the agriculture sector (2 NAMAs), in the transport sector (1 NAMA), in the energy sector (2 NAMAs), in the waste sector (2 NAMAs), in the buildings sector (1 NAMA) and in the industry sector (1 NAMA) (Ibid). However, it is not clear if or when these will go forward, as many of them are still being designed while others are looking for funding.

Colombia has also been active in the development of carbon markets. The country's INDC specified that it would explore the use of market instruments (Gobierno de Colombia 2015). It created a voluntary carbon market in mid-2015, focusing initially on the forestry sector (Environmental Finance 2016). In June 2017, with the support from the Partnership for Market Readiness (pmr), Colombia introduced a carbon tax for liquid fuels in its transport sector (equivalent to approximately USD 5 per tonne of CO2) payable by producers and importers of said fuels. Tax payers can offset or reduce the tax through the purchase of carbon credits from voluntary markets. It is expected that this option will create the demand for a robust carbon market (Colombian Ministry of Transport 2016; VCS 2018).

In addition, Colombia has been active in the UNFCCC's Clean Development Mechanism (CDM), under which 75 projects are listed. Projects mostly fall under hydro (25 projects) and landfill gas (19 projects) and the total cumulative emission reduction is estimated at 154 $MtCO_2e$ (UNEP DTU 2017).

2.6 Analysis of planned mitigation measures under the INDC and current mitigation strategies

To analyse Colombia's mitigation potential, we first examine the country's INDC implementation strategy and proposed mitigation measures.

As Colombia is moving towards the implementation of the INDC (IDEAM 2017c), the government decided to allocate emissions and mitigation measures to the different Colombian ministries instead of allocating them to the different IPCC sectors. This decision was taken because of a perceived need to assign clear responsibilities to different entities and track progress. Under the mandate of the CICC, an extensive analytical and political process followed in which the different line ministries have identified 33 prioritised mitigation measures (see below) based, among others, on the PAS and including discussions with the Ministry of Planning on the cost-efficiency of those measures. Emissions from deforestation have not been distributed to any specific ministry, rather deforestation is considered to be cross-cutting issue that needs to be addressed by all ministries.

Chosen (most cost-effective) mitigation actions per major line ministry include[5]:

Ministry of commerce, industry and tourism (selected measures only):

- Efficiency measures, including the promotion of good practices for installation, operation and maintenance
- Investments into technological conversion for energy efficiency
- Elimination of artisanal, informal ovens that emit GHG and other pollutants and reconversion
- to more energy-efficient chamber type ovens

Ministry of transport:

- Increase the number of electric taxis to 65,000 by 2050
- Increase the number of electric bikes to 42,000 by 2050
- Promote the use of Natural Gas Vehicles for public transport in Bogotá
- Introduce electric and hybrid vehicles in the public transport of passengers of the main cities of the country (981 buses by 2050)
- Introduce electric cars (26,000 by 2050)
- Promote rail freight as a complement/ alternative to road transport
- Introduce national days without cars (6 days per year for major cities)
- Provide infrastructure to support multimodality and intramodality in the operation of Public Transportation Systems. Pilots in 6 cities
- Change from fossil fuel combustion based cars to liquified gas driven cars (2% of all cars by 2028)

Ministry of housing, cities, territories:

- Reduction of 9% of solid waste entering final disposal sites by 2030, compared to baseline
- Reduction of 14% of solid waste entering final disposal sites (to incorporate in recycling processes)
- Reduction of 14% of solid waste entering final disposal sites (to incorporate to productive, agricultural and landscape chains)
- Mitigation through oxidation by burning CH_4 to CO_2 in 6 landfills that receive 60% of the country's waste

Ministry of mining and energy:

- Diversify energy generation sources, including through the development of large-scale renewable energy projects in the non-interconnected zones
- Promote energy efficiency initiatives in mining operations, including transportation, with the objective of reducing or optimising the consumption of fossil fuels
- Reduce fugitive emissions from extractive processes
- Reduce the difference in electric power consumption between peak and valley hours, encouraging electric power generation in off-peak hours from non-polluting sources and the promotion for the future implementation of new technologies such as smart grids and dynamic tariffs

[5] The process leading to the identification of the final retained mitigation measures is described in detail in the Third National Communication. These measures are intended to achieve Colombia's unconditional mitigation pledge. Please also note that there are no mitigation actions for the Institutional Commercial Stock Exchange included in the Third National Communication.

Ministry of agriculture and rural development (selected measures only):

- Rational pasturing
- Manure management in livestock (including increased usage of silvo-pastoral systems)
- Increase in permanent crops, forest plantations and tree fruits (palm oil, mango, avocado, rubber and cocoa)
- Implementation of the AMTEC system (mass adoption of technology)

Ministry of environment:

- Transform 100% of the national refrigeration production to efficient refrigerators that are free of HFCs
- Promote the implementation of "Thermal Districts"[6] to improve energy efficient buildings and replace the chillers that work with ODS and substances that have a high environmental impact
- Replacement of stoves with efficient cooking wood stoves

All Ministries:

- Reduce deforestation by 39% compared to baseline emissions

The prioritised mitigation measures are expected to overachieve the 20% conditional mitigation pledge put forward by the government by around 2% (Figure 9), although some additional measures are currently being analysed by the ministries. The mitigation potential from the currently identified measures is highest for deforestation followed by agriculture and energy and mining.

Figure 9: Emission reduction by 2030 based on prioritised measures by sectoral ministries ($ktCO_2e$)

Relevant ministry	Baseline emissions 2030	Expected emission reductions	Expected emission reductions through prioritised mitigation measures
Ministry of Energy and Mining	54,112	10,822	11,126
Ministry of Commerce, Industry and Tourism	46,389	9,278	3,079
Ministry of Agriculture	67,287	13,457	16,184
Ministry of Housing	26,913	5,383	930
Ministry of Transport	48,613	9,723	4,977
Ministry of Environment	2,264	453	6,987
Institutional Commercial Stock Exchange	3,407	681	67

[6] A Thermal District is an urban distribution network that produces steam, hot water and ice water - from a central plant and transports it by underground pipes to the buildings that make it up, in order to heat spaces, domestic water and / or to produce air conditioning.

Emissions from deforestation	88,435	16,687	32,400
Total	**332,420**	**66,484**	**75,750**

Source: IDEAM (2017c)

2.7 Additional mitigation potential

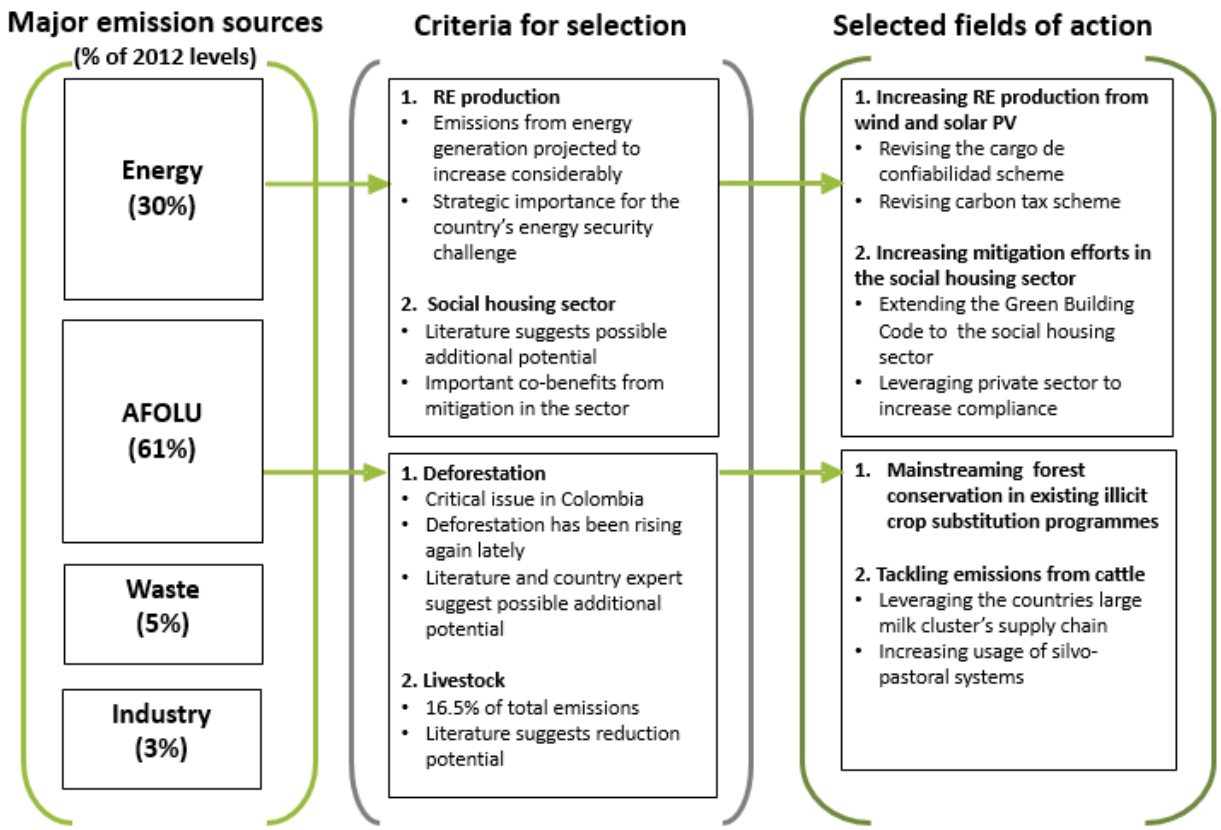
A majority of the previously mentioned prioritised mitigation actions have not been implemented yet and it is unclear when they will begin. Therefore, we identify specific measures in strategic sectors that, if successfully implemented, could yield to additional emission reductions. Moreover, the identified additional measures could support the country in achieving its conditional pledge of reducing emissions by 30% against the baseline.

The fields of action ("measures") in this section were selected based on the following considerations:

- historic and projected sectoral and/or ministry specific emissions development;
- emissions intensity;
- share of sector's/ ministry's emissions compared to the country's total emissions;
- existing emissions reduction measures or those currently under development;
- strategic importance;
- niche where more action/ ambition is possible;
- feasibility, and
- co-benefits.

As the previous chapters have shown, Colombia has already developed a range of measures for some other sectors. Plans are most advanced and detailed in the transport and waste sectors, where, in addition to prioritised mitigation measures, several NAMAs are already being implemented or designed. These sectors have thus not been chosen for the subsequent analysis. Instead, the focus in the following chapters is placed on detailed mitigation measures that could have additional impact beyond what is currently foreseen or expected (Figure 10).

Figure 10: Criteria for selecting fields of action



Source: Authors

Based on these considerations, leveraging the supply chain of the country's milk cluster in combination with an increased uptake and promotion of silvo-pastoral systems could be a first field of action for the agriculture sector/ministry. The proposed measure has a potentially large impact on emissions, which goes significantly beyond what is currently expected by the prioritised mitigation measures in this field.

Tackling deforestation through mainstreaming forest conservation into existing illicit coca substitution programmes has been chosen as an additional measure, which could be taken up by the agriculture ministry. In addition, emissions in particular from deforestation have risen again lately (IDEAM 2017c), potentially compromising efforts made in other sectors and creating a risk that the country will not be able to meet its INDC. Deforestation measures have not been assigned to any ministry in particular thereby creating a risk that the sector will receive less attention, although it is expected that all ministries will contribute to limiting deforestation.

The social housing sector has been selected given that current prioritised mitigation actions in this area fall short of meeting the expected emission reductions in the sector. In addition, the measures identified and analysed in this chapter closely align with similar analysis that is produced for the German emission trading authority for the conceptualisation of a market-based approach in the Colombian building sector. Mitigation actions in this sector are estimated to provide significant co-benefits.

Finally, the increase of renewable energy production (beyond what is currently targeted by the Ministry of Energy) has been chosen given its strategic importance for meeting the country's energy security challenge, but also for its effect on mitigation potentials in other sectors (e.g. transport, buildings).

2.7.1 Cattle emissions – sustainable agriculture practices & agreements with private sector

Inventory data from Colombia's Third National Communication estimates that emissions from agriculture amounted to 68.22 $MtCO_2e$ in 2012, 26.3% of total national emissions (including LULUCF). Livestock, mainly cattle, accounted for 42.75 $MtCO_2e$ or 16.5% of national emissions and is the main contributor to agricultural emissions. Livestock contributes to emissions through enteric fermentation (cattle, as part of livestock, produced 19.77 $MtCO_2e$ alone in 2012) as well as through direct non-CO_2 emissions (emissions from feed production and processing including land use change) (10.5 $MtCO_2e$ in 2012, mainly from cattle). Under baseline assumptions, emissions in the agriculture sector are expected to slightly decrease to 67.29 $MtCO_2e$ in 2030 (see Figure 9).

According to the 2014 National Agricultural Census, Colombia has 43.1 million hectares of agricultural land, of which 8.4 million hectares (19.7%) are used for crop cultivation, and 34.4 million hectares (80%) for pasture. Pasture land is used mainly for cattle ranching and hosts an approximately 21.5 million animals (DANE, 2014). Colombia's cattle herd count has been relatively stable over the last years and amounted to approximately 23 million animals in 2016 (FEDEGAN 2017) and cattle ranching has recently started to increase, following the peace agreement with the FARC and the subsequent return of demobilised fighters to their lands (The Guardian 2017). Colombia has the fourth largest stock of cattle in Latin America, behind Brazil, Argentina and Mexico and is among the top 13 producers in the world.

Today, there are approximately 500,000 cattle farms in Colombia, the majority of which are small farms. As such, 48% of cattle farms have less than 10 animals and 82% less than 50 animals. Cattle is mainly raised for meat and milk production. 5.4% of cattle is used exclusively for milk production, 17.8% exclusively for meat production and 38% for both meat and milk production. The remainder is largely breeding cattle (FEDEGAN 2016).

Colombia's economic milk cluster is highly concentrated. Although 45% of the processed milk is formally collected by 477 organisations, nine of them process 64% of the collected milk (Ibid). This structure could be leveraged to work with the private sector to promote sustainable practices in the milk cluster's supply chain.

The FAO estimates that the greatest emission reduction potential from livestock is the improvement of animal and herd efficiency. This could include better feeds, for examples mixes including legumes, and feeding techniques, for example digestibility enhancing techniques, leading to reduced methane emissions. Additionally, improving the management of grazing lands could increase productivity and lead to carbon sinks (Gerber et al. 2013).

Policies. Key agricultural policies focus on the expansion of agricultural crops, planning and land titling[7], reducing rural poverty by promoting rural housing as well as public goods and services, and the promotion of products in national and international markets (Ministerio de Agricultura y Desarrollo Rural 2011). Sectoral programmes aim at implementing the agricultural aspects of the peace agreement with FARC. In particular, cattle related policies focus on supporting the producers to

[7] Land titling describes a form of land reform in which private individuals and families are given formal property rights for land which they have previously occupied informally or used on the basis of customary land tenure.

reach international markets, implementing agricultural good practices, improving animal health, and supporting the local producers' associations, both in the dairy and beef clusters.

Additional national policies aim to improve the competitiveness of the dairy sector by prioritising public resources to reduce the production costs at the farm level, promote horizontal and vertical integrations, develop productive clusters, supply national and international markets with high quality dairy products and strengthen the institutional framework (CONPES 3675).

The Ministry of Agriculture also initiated a process for the formulation of a national policy for sustainable livestock, in close cooperation with the Ministry of the Environment.

2.7.1.1 Measures that could increase mitigation potential

The dairy sector is characterised by few big dairy national and multinational companies and many small farm producers. Seven big companies (including multinationals such as Nestlé, Parmalat and Danone) process more than half of the country's milk production (Proexport 2011). These companies could be leveraged to work with the many small producers in their supply chain to implement best farming practices that can improve productivity, milk quality and reduce emissions from cattle. This efficiency measure in turn can have positive impacts on revenue and profits. Given the large share of low productivity cows in total cattle emissions (18% of total emissions from cattle) (IDEAM 2017c), implementing good practices could offer a significant mitigation potential.

Evidence from available good practices in a number of countries in South America project a mitigation potential that ranges from 14 - 41% against baseline emissions, equivalent to a reduction of 6.32 – 18.52 $MtCO_2e$ compared to emissions in 2012 (Gerber et al. 2013). This would decrease emissions from the agriculture sector by between 9 to 27%.

Additionally, Colombia could also work towards an improvement of grazing lands, through the introduction and increased usage of silvo-pastoral systems (beyond what is currently included in the prioritised mitigation measures by the Ministry of agriculture and rural development) in which forests are integrated with forage and livestock production systems.

Colombia's low carbon development strategy includes an estimate of the mitigation potential of the conversion of 365,000 ha of conventional land into silvo-pastoral land-use systems (Table 5) (Universidad de los Andes 2016). Implementing this measure is estimated to require investments in the range of 700 million USD. Silvo-pastoral systems could also be promoted by milk producers in their supply chain, especially on farms with low productivity cows. Case studies are available documenting the promotion of silvo-pastoral systems in the supply chain of Nestle in Colombia (Tafur et. al 2011). Also, the Global Environmental Facility (GEF) project "Sustainable Livestock in Colombia", which is focusing on demonstrating the benefits of sustainable livestock practices implemented by small land owners, provides valuable experience in the performance of silvo-pastoral systems in the country. Challenging could be a possible rebound effect by which the emissions per cattle diminish while the number of cattle overall increases which in turn could lead to agricultural intensification and increased deforestation. Therefore, these measures would have to be accompanied by complementary policies, for example through the removal of financial support for unsustainable practices or by agreeing with landowners on a certain thresholds/ area that can maintain minimum percentage of forested area. Evidence from other countries, e.g. Brazil, could be used in this context (Latawiec et al. 2014).

Current prioritised mitigation measures by the Ministry of Agriculture are expected to lead to cumulative emission reductions of 16.19 $MtCO_2e$ by 2030. However, the mitigation potential of silvo-pastoral systems alone is almost three times higher. There is thus reason to believe that additional emission reductions could be achieved through the proposed measure.

Table 5: Estimated mitigation potential of silvo-pastoral systems (2015-30)

Total cumulative mitigation potential in 2030 ($MtCO_2e$)	48.86
Annual mitigation potential ($MtCO_2e$)	3.26

Source: Universidad de los Andes (2016)

Given that most of the technologies and practices that mitigate emissions also improve productivity, there are important co-benefits associated with this measure, including food security and poverty alleviation. Silvo-pastoral systems can also provide additional income to farmers, through thinning and timber production. Trees can increase the amount of sequestered carbon in biomass.

2.7.1.2 Barriers to implementation

One of the main barriers for the implementation of the proposed measure is the low technical level of small scale cattle farms. Other important barriers include low access to credit and financial resources to invest in the farm, informal land tenure, and a general reluctance to implement new practices due to traditional and cultural beliefs.

To overcome the financial resource barrier, multinational companies might have an interest to provide initial funding especially if they are to benefit from the adoption of best practices within their supply chain. Similar programmes already exist (e.g. CDP's supply chain action exchange programme). If the government could provide initial guarantees, local banks might also be willing to provide loans for this measure.

Local governments could also engage with small farm producers through education and knowledge sharing programmes to inform those producers of the benefits of such a measure. In addition, international donors and implementing agencies could also support by implementing pilot projects.

2.7.2 Reducing deforestation – mainstreaming forest conservation in existing illicit crop substitution programmes

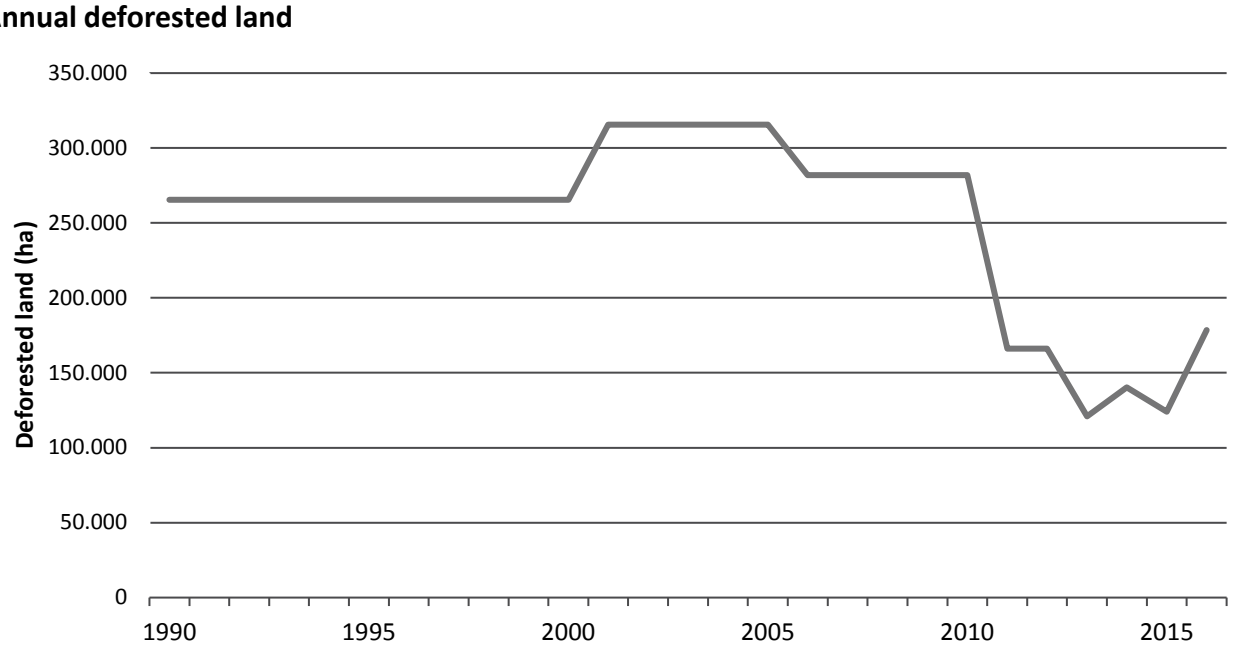
The annual deforestation rate in Colombia has decreased from an average of 315,602 ha/year in the period 2000-2005, to 124,035 ha/year in 2015 (IDEAM 2017a). Consequently, emissions from deforestation have slowed down from 122.71 MtCO2e in 2000 to 92.35 MtCO2e in 2012 (Third National Communication data). However, recent data shows that emissions from deforestation have started to increase again, with the deforestation rate reaching 178,597 ha in 2016 (see Figure 11) (Ibid).

At the national level, the main drivers of deforestation are the expansion of the agricultural and livestock frontier (small-scale and agro-industrial), the expansion of infrastructure (mainly roads) and extractive activities (e.g. extraction of minerals and hydrocarbons, logging) performed legally and illegally (Forest Carbon Partnership Facility 2017). Although illicit drug cultivation, mainly coca, has a small direct effect on deforestation, which transforms only small areas of forested land, it is an important indirect driver of deforestation. Coca is mainly cultivated deep inside the forests[8] to prevent its cultivation from being detected and thus potentially from being forced to eradicate plantations. Therefore, coca plantations cause agricultural and livestock frontier expansion as well as

[8] Forest reserves are publicly owned land.

infrastructure expansion in forests reserves and protected areas. Consequently, it is estimated that as much as 30% of the deforestation in 2015 was caused by coca cultivation (GIZ 2017).

Figure 11: Colombia's deforestation trend



Data source: IDEAM (2017b)

According to the most recent official reports, the cultivation of coca increased from 96,000 ha in 2015 to 146,000 ha in 2016, an increase of 52% (UNODC 2017). The main reasons for this increase in coca cultivation are the government's suspension of fumigation, the expectation to receive financial aid or compensation for coca substitution following the peace agreement with the FARC, and the effects of a depreciating Colombian Peso (Ibid).

Policies. Colombia is formulating a REDD+ national strategy led by MADS with support from the World Bank Forest Carbon Partnership Facility (FCPF), the UN REDD programme and the GIZ. The request for funding to the FCPF focuses on: (1) consultation and participation through local dialogues and dissemination with the indigenous and Afro-Colombian sectors, dialogue spaces and communication with civil society at the subnational level and the promotion of national/international instances for dialogue and dissemination of the REDD+ strategy; (2) preparation of the REDD+ strategy through the development of enabling measures for REDD+ pilot projects and national and regional institutional strengthening; and (3) forest monitoring and safeguards system with the implementation of the community monitoring protocol, the monitoring of causes and agents of deforestation, the operation of the Safeguards Information System, reporting and the follow-up safeguards implementation.

Within this process, several REDD+ strategy options have been identified: environmental territorial ordering, community strengthening for forest management, forest ecosystems ordering and management, development of forest conservation incentives, promotion of sustainable sectoral practices, promotion of national protected areas and promotion of alternative development illicit crop programmes.

Additionally, Colombia has been designing and implementing actions through performance-related pay schemes. In this regard, a Joint Statement of Interest was signed with the governments of Norway,

Germany and the United Kingdom with two objectives at the national level. The first corresponds to the design and implementation of policies and structures that permit the reduction of emissions from deforestation by promoting a low-carbon economy, and the second to a performance-related pay scheme in the Amazon region, with the development of the REM/Amazon Vision programme, to achieve zero net deforestation by 2020.

In the last 15 years Colombia has implemented two types of policies against drug cultivation: control measures such as fumigation and mandatory eradication, and alternative development strategies such as voluntary eradication, promotion of alternative crops and financial aids (GIZ 2017). Following the FARC peace agreement, the government is now implementing voluntary eradication and territorial development programmes as its main strategy against coca cultivation (UNODC 2017).

The voluntary eradication programme offers the coca landholders several subsidies to support their transition to legal productive activities. The monetary subsidies include an upfront and a monthly payment during the first year, a financial aid for an alternative production project for two years, and technical assistance during the entire process (Presidencia de la República 2017). The subsidies are conditional on the commitment to eradicate the coca plantations.

However, the agreements do not include any provision for forest conservation or stopping the expansion of the agricultural frontier.

2.7.2.1 Measures that could increase mitigation potential

Eliminating coca cultivation completely could significantly reduce deforestation and decrease emissions by around 25.1 $MtCO_2$ cumulatively (based on inventory data from the Third National Communication) or 53,579 hectares, assuming a proportional increase of the share of coca cultivation related deforestation in 2030. While completely eradicating coca plantations might not be feasible or desirable, given its economic importance to farmers, even reducing coca cultivation by half could help Colombia achieve, implement or overachieve its expected emission reductions of 32.4 $MtCO_2e$ or 39% by 2030, against baseline emissions. Given that the different ministries have not yet detailed how exactly they can help or intend to achieve the 39% reduction goal and that there is no particular ministry assigned to mitigate emissions from deforestation, a detailed measure as the one proposed here might help increase the chances that one ministry (e.g. Ministry of Agriculture) could take this up.

The implementation of policies that promote alternative crops and activities for coca substitution could lead to an increase in agricultural activities, and therefore also contribute to deforestation. Therefore, forest conservation strategies could be integrated in current coca substitution agreements. Importantly, this measure would not imply a change in the current strategy for coca substitution, but complement current coca substitution efforts with a forest conservation component.

In practice, the creation of payments for environmental services and the promotion of sustainable forest management (sustainable use of timber and non-timber products) could be envisaged and integrated into such agreements, for example.

At the same time, it would also be important to promote economic alternatives and crops that are suitable to the characteristics of the regions, in particular to the soil and water availability, and that can benefit from forest areas, such as cocoa and rubber plantations.

A case study of this type of measure is the joint activities in the Chocó region, carried out under the USAID's Bioredd programme and the agency in charge of the substitution of illicit crops (Unidad Administrativa para la Consolidación Territorial). These institutions promote the sustainable use of non-timber products (a palm fruit called *açai*) with 373 families in Chocó as a strategy to improve incomes and prevent illicit crops (BIOREDD USAID 2015).

2.7.2.2 Barriers to implementation

One of the main barriers to implement this measure is the current lack of interagency coordination considering that there are numerous institutions in different sectors working in the areas that would need to come together and intervene jointly. Currently, a directorate in the Presidency, which coordinates with departments and municipal governments, implements the national programme for the integral substitution of illicit crops (Decree 896 of 2017). For the implementation of the proposed measure, the programme has to include both the Ministries of Environment and Agriculture at the national level, the regional environmental authorities (CARs per region), as well as entities specialised in forest management and monitoring (Presidencia de la República 2017). In addition, there is a lack of national entities specialised in forest management. For a successful implementation of the proposed measure, different regional entities have to be involved which makes it difficult to coordinate the national efforts.

Another barrier is the few technical and economic viability studies for timber and non-timber products in the forest regions.

2.7.3 Social housing

GHG Emissions. Projections for the growth of GHG emissions as well as emission reduction potentials in the housing sector are specified in the housing sectors' Sectoral Action Plan (PAS) that was developed in 2014. Emissions in the housing sector are estimated to increase at an annual growth rate of 3.3%, reaching 17 $MtCO_2e$ per year in 2040, and 339 $MtCO_2e$ accumulated over 2010-2040 (Ministerio de Vivienda Ciudad y Territorio 2014).

Between 2007 and 2015, approximately 95,000 housing units of social interest (VIS), 51,000 housing units of priority interest (VIP) and 185,000 general housing units were built per year. These housing units are projected to increase in the future, due to demographic growth as well as increased migration, especially from Venezuela. Depending on the climate zone and the type of housing, each housing unit causes annual CO_2 emissions of 0.5 to 1 tCO_2/yr from electricity and gas use. A typical social housing unit causes approximately 0.6 tCO_2 emissions/year due to electricity and gas consumption.

Policies. Colombia's Green Building Guide, adopted in 2015 (Decree 1285/2015 and Resolution 0549/2015) and developed by the Ministry of Housing, in close consultation with IFC and CAMACOL, establishes targets for energy and water efficiency in seven different building types: hotels, hospitals, offices, commercial centres, schools, housing (non-VIS), and social housing (VIS/VIP); and in four different climatic zones: cold, temperate, hot and dry, and hot and humid. It also provides a list of measures that can be applied to achieve the targets. Targets and measures applicable to the social housing segment are currently optional.

In addition, compliance with both mandatory and optional targets is verified through auto-declaration only. The Ministry of Housing is currently working on a monitoring and verification scheme to supervise compliance. A specific sanction scheme does not exist.

A housing NAMA is currently under development by the Ministry of Housing and supported by USAID. No proposal has yet been submitted to the UNFCCC. The NAMA targets displaced and vulnerable people in informal settlements and includes waste, energy, and mobility components. Its objective is to reduce GHG emissions from the housing sector, through comprehensive and sustainable land planning through spatial interventions that guarantee the recovery of degraded areas and the resettlement of population at risk from climate change, among others (IDEAM 2017c). The scope of the housing NAMA is thus initially limited to informal settlements (communities or neighbourhoods), in particular areas that have been defined as "in need of improvement" under the Territorial Development Plans (Planes de Ordenamiento Territorial – POT). However, it is estimated that the scope of the NAMA may expand

over time. The methodology to be developed under this NAMA to calculate the reduction of GHG emissions is expected to be also applicable to other projects related to interventions of urban development.

Outlook. The housing sector, and in particular the social housing segment, is part of Colombia's National Development Plan (PND) for 2014-2018. The PND envisages a reduction in the urban housing shortage, amongst others through the design and implementation of specific programmes, such as "Viviendas Gratuitas" (a 100% home purchase grant) and "Mi Casa Ya" (a subsidy scheme with different types of subsidies for home purchase), as well as through the design of financing instruments that facilitate access to housing while at the same time promoting sustainable construction and energy efficiency. This is supported through the allocation of subsidies in money or in kind for the acquisition of a new house, coverage of interest rates on mortgage loans, residential leasing contracts or purchase or lease-purchase options, or a combination of these instruments.

The PND aims for the construction of an additional 800,000 urban housing units (VIS, VIP, and No-VIS) by 2018, compared to 2014. Of these, 300,000 housing units are planned to be built in the VIS and VIP segment, amongst others under the mentioned programmes implemented by the Ministry of Housing.

2.7.3.1 Measures that could increase mitigation potential

Current prioritised mitigation measures by the Ministry of Housing would bring down emissions by 0.93 $MtCO_2e$, which is lower than the earlier expected emission reductions of 5.83 $MtCO_2e$ by 2030 and far below an estimated maximum emission potential of 28 MtCO2e by 2040 compared to 2010 levels that was detailed in the sector's PAS (Ministerio de Vivienda Ciudad y Territorio 2014).

While the Green Building Code targets the energy and water efficiency of the building sector in general, it is not mandatory for the social housing sector. However, buildings that will be constructed in the social housing sector will stay for many years, so it is vital that buildings are constructed in the most energy efficient way possible, to avoid a lock-in of future emissions. Therefore, the Green Building Code targets for energy and water could also be made mandatory for the social housing sector. If no action is taken and assuming constant energy use, the 300,000 new VIS and VIP housing units would emit 150 to 300 $ktCO_2$ per year.

The recommended savings for energy and water for the VIS/VIP in the 1st year amount to 10% against the baseline (see Figure 12 and Data source: Ministerio de Vivienda Ciudad y Territorio (2015)

Figure 13). In the second and following years, the recommended savings amount to between 15 – 20% for energy use, depending on the climatic zone, and 10-15% for water consumption (Resolution 0549/2015). Applying all recommendations from the Green Building Code, could decrease emissions from energy and water usage by around 25 $ktCO_2/y$ per housing unit.

Compared to international good practice, the Colombian Green Building Code targets seem to be quite ambitious. For comparison, definitions for nearly zero energy residential buildings in the European Union range from around 20 – 160 kWh/m2/yr , meaning that in many EU countries the maximum defined primary energy consumption for nearly zero energy residential buildings is actually above current values for Colombia's VIS and VIP (BPIE 2016).

Figure 12: Baseline energy consumption in the social housing sector (kwh/m^2 - year)

	Cold	Temperate	Hot and dry	Hot and humid
Housing units of social interest	44.6	44	34.6	49.3
Housing units of priority interest	48.1	53.3	44.9	50.6

Data source: Ministerio de Vivienda Ciudad y Territorio (2015)

Figure 13: Baseline water consumption in the social housing sector (lt/person/day)

	Cold	Temperate	Hot and dry	Hot and humid
Housing units of social interest	105.7	113.9	156.7	125.4
Housing units of priority interest	78.1	98.3	189.8	110.6

Data source: Ibid.

In addition, Green Building Code targets could be included in the support programmes by the Ministry of Housing. For example, the 100% home purchase grant could only be granted for green building certified buildings.

With the Green Building Guide in place, its successful enforcement is one of the biggest challenges Colombia faces. Working with the private sector can help to ensure greater compliance with the Green Building Code. For example, the government could work more closely with Colombia's construction companies and project developers, making sure they are aware of the Green Building Code and understand the benefits of energy efficient constructions.

The government could also make the study of the Green Building Code mandatory in training curricula for construction workers and project developers. While helping to increase uptake of Green Building Code targets by the construction sector and project developers, this measure could also create capacities for better monitoring and verification of targets under the Green Building Code.

Lastly, specific tax incentives could also be created to increase demand for Green Building Code compliant housing.

Recent studies show that the estimated costs of applying the Green Building Code recommendations to the social housing segment would be cost-efficient. For VIP units, the cost is estimated to amount to 2.7% of the building costs or about 600 EUR per housing unit and for VIS units, the cost would be 1.2% or about 270 EUR (based on forthcoming study by NewClimate Institute together with Öko-Institut in a project undertaken with the German emission trading authority (DEHSt/UBA *FKZ* 3715 42 506 0).

Co-benefits of this measure include positive effects on the health of the habitants of social housing, due to better indoor air quality. The measure could also have development benefits as energy efficient buildings can help lift people out of energy poverty and decrease energy and water bills.

In addition, there are strong synergies with other sectors, such as energy and transport. For example, reductions in the energy demand of a building would have a strong impact on the overall energy sector, while lower emissions from the energy supply sector would contribute to lower emissions from the building sector, including social housing.

2.7.3.2 Barriers to implementation

One of the main barriers to implement this measure is the lack of financial resources for social housing investments due to the current economic slowdown and fiscal restrictions. Further provisions of tax or other kind of monetary incentives might thus be difficult.

Other barriers include (perceived) higher costs for green building certified housing units and a general lack of awareness by the inhabitants of social housing units as well as the construction and project developers alike.

However, leveraging the private sector might not be hugely costly. Especially the integration of the Green Building Code into school curricula, the better coordination and information exchange with

private sector organisations as well as the integration of green building clauses into existing public support schemes could likely be done at little cost.

2.7.4 Increase renewable energy production from wind and solar PV

Installed capacity. Economic growth, greater public spending power and urbanisation have led to a doubling of energy consumption over the past 25 years, which reflects a steady annual growth rate of energy demand by around three to four percent (Briscoe et al. 2016).

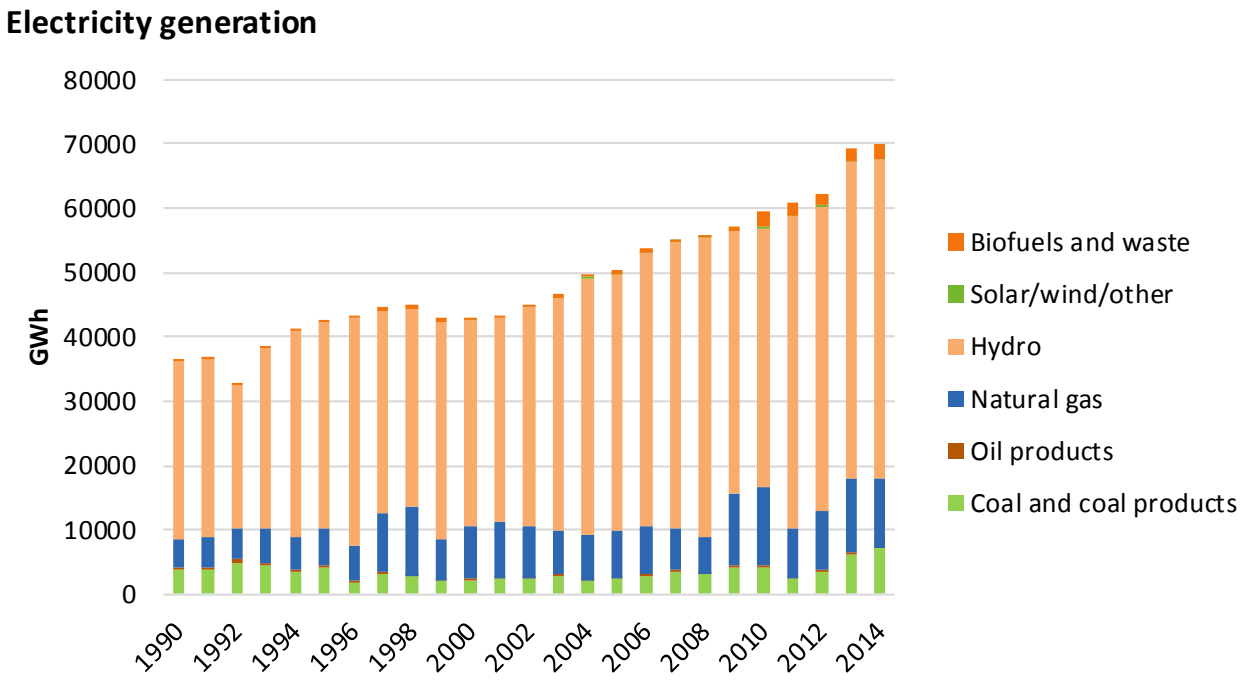
Colombia's total installed power-generating capacity is 15.5 GW and production stands at 136 TWh/a, which is projected to expand to 20 GW and 175 TWh/a by 2028. While electricity is largely generated by hydropower, coal-fired electricity capacity has been the fastest-growing technology in Colombia's electricity mix (Figure 14). One of the major reasons behind this increase in coal-fired electricity capacity is Colombia's objective to increase energy security. Colombia is highly dependent on hydropower for the country's electricity generation, however, due to increasingly severe and more frequent droughts this very dependence has become a challenge. In 2014, 10% or 7,100 Gwh of electricity were generated by coal and coal products (IEA 2016e). Under current policies, it is expected that this share continues to grow. 35% of Colombia's coal is already used for power generation and an additional 250 MW of coal-fired capacity is already under construction.

Solar and wind PV resources, although with high potential[9], have been largely untapped and are virtually non-existent in the current energy mix. Expanding renewables instead of fossil fuels to meet growing energy demand thus has important potential to prevent future emissions increase (also see chapter 2.8 on coal).

A study published by Norton Rose Fulbright claims that large scale onshore wind and geothermal would already be able to achieve the same cost/KW as that of current hydroelectric generation in Colombia while the perceived cost of renewables remains much higher (Norton Rose Fulbright 2017). Another study by Lazard, comparing the levelized cost of energy for various conventional and renewable technologies, finds that the unsubsidised levelized cost of energy for utility scale solar PV and wind in the Americas is already below that of coal (43 – 193 and 30-50 USD/MWh compared to 60 – 143 USD/MWh respectively). Even when taking into account the impact of the availability and higher capital costs, correspondingly higher levelized costs of energy for utility scale solar PV and wind would still likely be cost competitive with coal (Lazard 2017).

[9] The Guajira Peninsula has class 7 winds which, in South America, is comparable only to Patagonia. Guajira also has solar radiation of close to 6 kwh per m^2, in comparison the Chilean Atacama Desert has radiation of about 7-7.5 kWh/m^2, and the Mexican Sonoran Desert 6-7 kWh/m^2.

Figure 14: Colombia's electricity generation by source 1990 - 2014



Data source: IEA World Energy Balances (2016)

The Colombian electricity sector has an emission factor of 374 g CO2/kWh (Ministerio de Minas y Energía 2014). This is comparatively low due to the large share of hydropower in the sector.

Energy security. Energy security is an important issue due to increasingly severe droughts (e.g. in 2016, linked to El Niña and El Niño effects). In 1994, a market-based guarantee scheme (Reliability charge - cargo de confiabilidad) for energy producers has been created to increase energy security. The current reliability charge is based on a revised scheme of 2006. It consists of a fixed payment energy producers receive akin to paying for installed capacity when, for example, there is a shortage of energy supply due to drought (Comision de Regulacion de Energia y Gas - CREG 2017). One of the essential features of this scheme is the Firm Energy Obligation (OEF), which is a commitment on the part of the energy producer backed by a physical resource capable of producing firm energy during scarcity periods. The energy producer who wins the OEF tender receives a fixed compensation during a specific time period and, in exchange, commits to deliver a determined quantity of energy when there is a shortage of energy and energy prices soar above a pre-defined scarcity price (Ibid). At the same time, this scheme also works as guarantee for investments in energy generation to meet increasing demand.

Solar PV and wind energy are excluded by definition from the *cargo de confiabilidad* as they are not considered to being able to guarantee a specific production of energy at every point in time due to their inability to store electricity.

In this context, there is also some pressure to increasingly use coal and other thermal options for energy production. In fact, coal-fired electricity capacity has been the fastest-growing technology in Colombia's energy matrix: from 6.3% of the total matrix in 2010 to 8% in 2016, reaching 1,393 MW. (Briscoe et al. 2016). An additional 250 MW is under construction and, by July 2017, another 550 MW have been announced (Global Coal Plant Tracker 2017). These would lock in emissions for years.

Policies. The sectoral action plan of the mining and energy sector from 2014 has four main objectives: increase energy efficiency, decrease fugitive emissions from extractive processes, diversify the country's energy generation and reduce energy demand (IDEAM 2017c).

The 2014 law on renewable energy (law 1715/2014) intends to foster partnerships between the national government, the private sector and local authorities to bring about greater production and use of renewable energy sources. The law also establishes a fund to support renewable sources as well as different financial incentives for renewable energy investments, income tax exemption, accelerated depreciation of assets, value-added-tax exemption and import duty exemption. Concrete details of the incentives and financial support for these measures have since been issued although concerns persist over, e.g., bureaucratic hurdles that stand in the way of access to tax rebates (Briscoe et al. 2016).

Energy policy in Colombia is conducted according to the technological neutral principle to ensure cost effectiveness. Therefore, renewable energy will have to compete with hydro and other sources of energy. Regarding the reliability scheme, resolutions 243/2016 and 061/2015 by Colombia's Energy and Gas Regulatory Commission (CREG) also specify methodologies for solar PV and wind energy for the determination of firm energy so that eventually renewable energy might be included in the reliability market scheme (IDEAM 2017c). Nevertheless, due to the technological neutral principle it remains questionable if renewable energy can economically compete if the *cargo de confiabilidad* is not changed itself.

2.7.4.1 Measures that could increase mitigation potential

The share of wind and solar PV is less than 0.5% of Colombia's total installed capacity. Under the BAU scenario, wind and solar PV are projected to only increase marginally (Figure 7).

Table 6: Current and BAU installed capacity (MW) for electricity generation by technology

Technology	2014	Grid share %	BAU 2030	Grid share %
Hydropower	10,772	69.6%	14,857	69%
Gas	3,909	25.3%	3,841	18%
Coal	701	4.5%	2,075	10%
Oil	0	0%	0	0%
Biomass	53	0.3%	67	0%
Wind	18	0.1%	474	2%
Other	25	0.2%	88	0%
Total	**15,478**	100%	**21,402**	100%
Total share of renewables (incl. hydropower)		70%		71.9%

Source: UPME (2015)

However, the development of renewables offers a substantial untapped emission reduction potential of 38.8 $MtCO_2e$ by 2030 (Table 7) equivalent to a share of 73.6% share of renewables (including solar PV, wind and hydro) by 2030. To reach this target, it would be necessary to increase the combined solar PV and wind installed capacity by an additional 354 MW. The total investment required to achieve the target is estimated to 90 million USD over the period 2015-30 (Universidad de los Andes 2016).

This compares to an expected mitigation potential from the corresponding chosen mitigation measures of 11.13 $MtCO_2e$ which is thus much lower than the overall potential.

Table 7: Estimated mitigation potential – increase of RE in the national grid (2015-30)

Total cumulative mitigation potential in 2030 (Mt CO2e)	**38.79**
Annual mitigation potential (Mt CO2e)	2.59

Source: Universidad de los Andes (2016)

Critics of the current *cargo de confiabilidad* claim that it is badly designed, lacks transparency, and needs to be amended if it is to address the true energy needs of the country (James 2017). The government could therefore revise the scheme so that it allows for wind and solar PV energy producers to successfully participate in OEF tenders and access the *Cargo* payments.

This could be done by incorporating the multiple co-benefits of renewable energy production in this scheme so that the levelized cost of renewables is competitive to those of other energy sources.

The cargo scheme is currently being discussed. Despite the energy supply it is supposed to guarantee, the scheme did not deliver during the recent droughts. It would thus be a good opportunity to discuss an overhaul of the capacity scheme including the inclusion of renewables into it.

Another possibility would be to incorporate the demand side in the *cargo de confiabilidad*, rather than energy supply alone.

Currently the carbon tax only applies to liquid fuels. To mitigate climate change, the government could internalise the cost of pollution and include coal into the existing carbon tax which when it was first designed, the inclusion of coal was successfully lobbied out (authors information). For example, the government could try to bring coal in again by illustrating its true costs to society. By doing so, renewable energy would also become relatively more cost competitive.

Co-benefits of these measures include environmental benefits such as better air quality, less water pollution, but also increased energy security.

2.7.4.2 Barriers to implementation of increased wind and solar energy production

One of the major barriers is that the public sector controls the vast majority of generation and has little interest in attracting new investors. Electricity generation is concentrated in five companies in a market comprised of 46 entities. In 2015, the five largest companies generated more than three quarters of the electricity supplied for the year — and significantly, three of the five companies are either government owned or public-private partnerships (James 2017).

Another technical barrier is the transmission grid which currently does not reach the Guajira Peninsula, where most of wind and solar resources are located. There are vague plans to expand there by 2023 and a NAMA “Zona No Interconectadas” is currently under development by MADS and the Ministry of Mining and Energy (MME) which aims at the expansion of energy grid to non-connected areas of the country (IDEAM 2017c).

2.8 Assessment of the relevance and perspectives of coal use

Colombia is a country with large reserves of oil, gas and coal. Its coal reserves amount to 0.8% of global reserves, and they are the largest in Latin America (World Energy Council 2013). Colombia is the eleventh largest producer of coal and the fourth biggest exporter in the world. While domestic use of coal is only 3% of the coal production, it has rapidly increased in recent years.

Against this background, this chapter explores the role and perspectives of coal for Colombia: starting with an overview on the economic role of coal more broadly, and a detailed analysis of the country’s position as a major coal exporter, we then analyse the historic and current domestic use of coal. In addition, we give an overview of local impacts of coal use and mining, followed by a brief analysis of

the country's coal phase out potential.

2.8.1 The economic role of coal

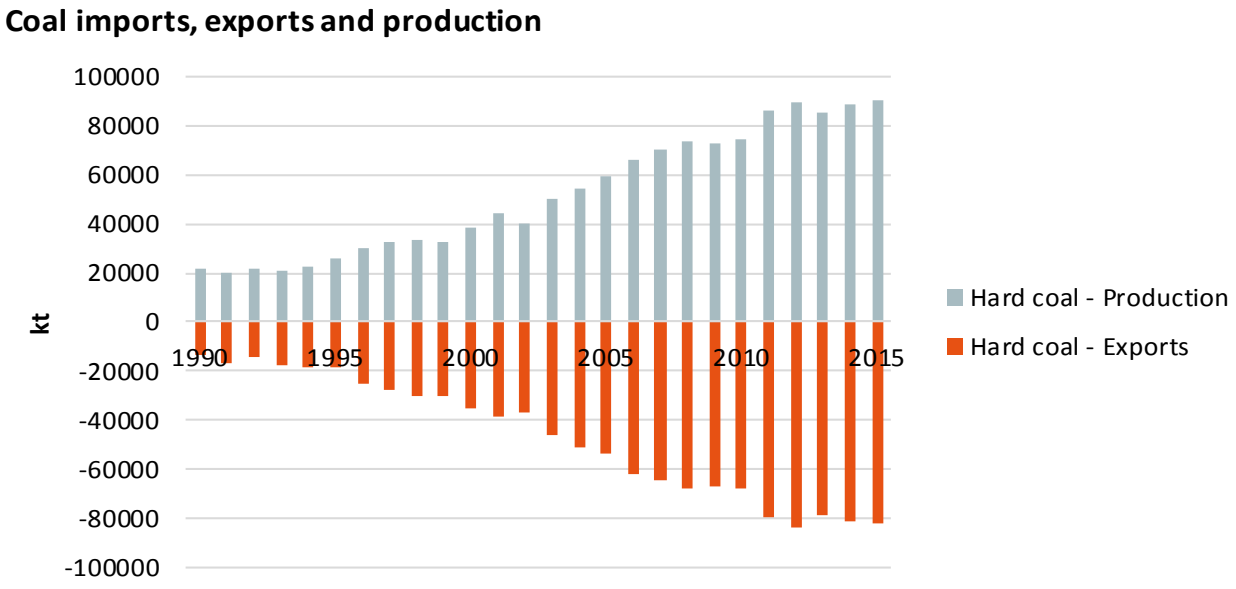
Coal production and coal trade

In Colombia, coal has been a pillar of the national economic development strategy, together with other parts of the mining and energy sectors. The country's National Development Plan (2014-18) has a focus on the extractive, including coal, sectors. Coal exploration was actively encouraged under President Uribe Velez (2002–2010), and has continued since then under President Santos (Strambo & Velasco 2017).

Coal production has significantly increased over the last years. Relatedly, coal mining for export has also soared in Colombia, with production having increased by 80% since 1999 (World Energy Council 2013).

In the past, Colombia has not produced as much as they intended to due to a mixture of decreasing global demand and low international prices of coal (Strambo & Velasco 2017). Nevertheless, production stood at a record high of 91 million tonnes in 2016. Around 95% of extracted coal is exported (Figure 15). Colombia is the world's fourth largest coal exporter and eleventh largest producer (IEA 2016d).

Figure 15: Coal extraction, import and export in Colombia (1990 - 2015)



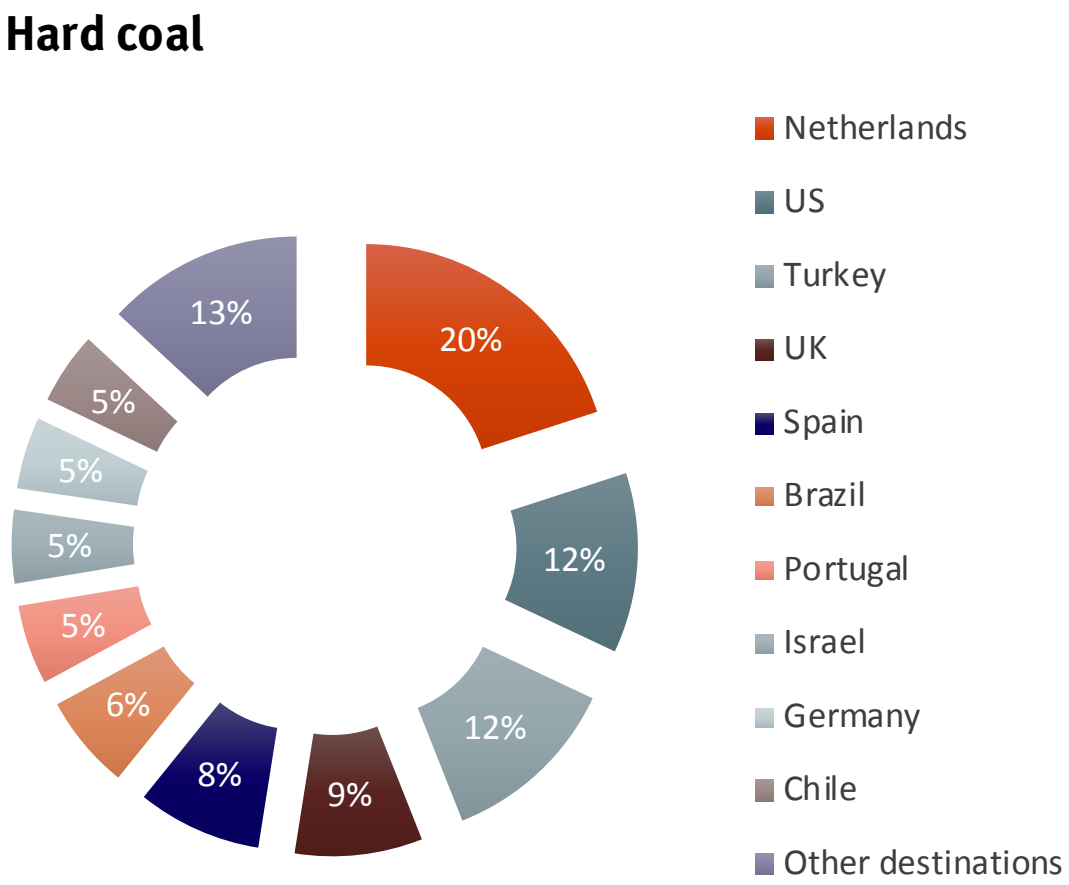
Data source: IEA World Energy Balances (2016)

Colombia is considered to be a low-cost producer whose coal is highly sought after due to its low sulphur content (World Energy Council 2013). Due to shorter distances compared to other geographies (such as Australia and much of Asia) with resulting lower freight costs and the high quality of its coal, Colombia exports most of it to European and American markets. Two-thirds of production is exported to Europe, and 20 percent to other countries in Latin America. In 2016, the largest importer of Colombian thermal coal was the Netherlands with 17.26 million tonnes (S&P Global Platts 2017). In 2015, Germany was the ninth largest importer of Colombian coal briquettes (MIT 2017). However, this is an indirect import. In fact, Germany gets the Colombian coal through the Netherlands which exports 73% of Colombian coal to other countries, mostly Germany (87%) (Garcia

et al. 2017). Another twelve percent was directly exported to the United States, representing 73 percent of US coal imports (also see Figure 16) (Briscoe et al. 2016).

The recent widening of the Panama Canal will benefit Colombian coal exports in the future, further decreasing the distances that the country's coal has to travel to its main export markets in the EU and the US and therefore leading to decreasing shipping costs (Pao-Yu Oei; Roman Mendelevitch 2016).

Figure 16: Colombian coal exports destinations in 2014



Data source: OEC - the Observatory of Economic Complexity (2017)

Geographic distribution of coal mining

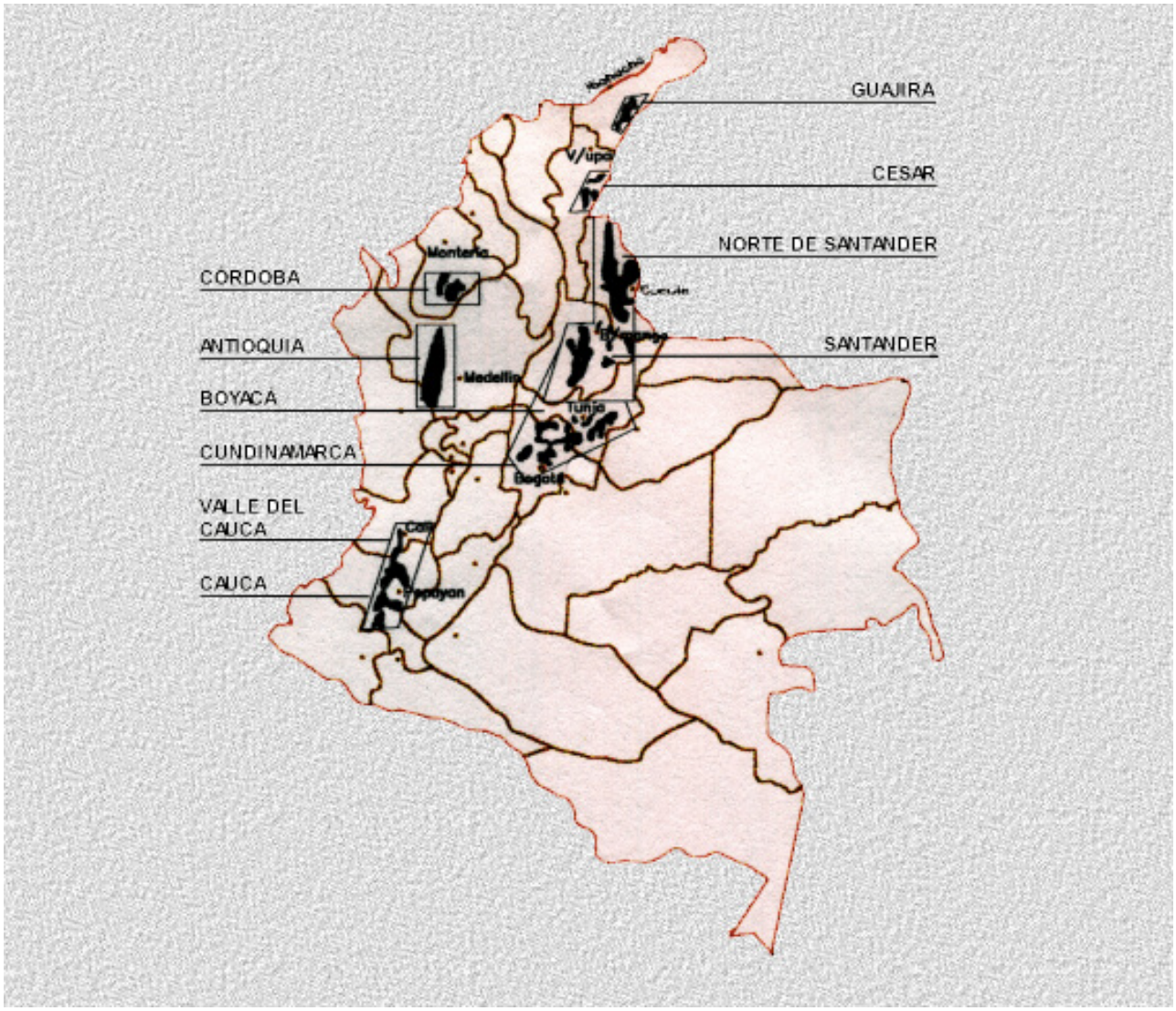
90% of Colombia's coal is extracted from remote areas in the north and the west of the country, in particular the Guajira Peninsula and Cesar (Agencia Nacional de Minera 2014). The development of Colombian coal for export has centred in particular on the Cerrejón deposits, the country's biggest open pit coal mine, on the Guajira Peninsula (World Energy Council 2013). In 2015, more than 90% of coal exports came from mines in La Guajira and Cesar (UPME 2016). More than 92% of coal extraction is done in open pit mines (Zárate & Vidal 2016).

At the same time, coal production strongly varies depending on the geographic location: On the one hand, coal produced in the north represents approximately 90% of Colombia's total production, and 99% of the production is exported. It is produced in large scale by multinational industries that in the past were repeatedly embroiled in controversies about their labour standards and environmental track record (The Guardian 2016).The Colombian state owns all coal reserves and unlike the oil sector,

private, mostly large multinational companies operate coal mines under concession contracts with the state (World Energy Council 2013). The biggest coal companies include BHP-Billiton (Australian-British), Glencore (Anglo-Swiss) and Drummond (American).

The coal produced in the inner parts of the country, on the other hand, is mainly used for domestic consumption (30% is exported), has a medium to small production scale, is less pure and is made by medium and small producers, some of them informal (Salazar, Benavides, Cabrera, & Zapata, 2011).

Figure 17: Map of Colombian coal reserves



Data source: UPME (2017)

Relevance of coal for the Colombian economy

Coal plays an important role for Colombia's economy, contributing to around 1-2 percent annually of GDP. In 2015, coal contributed to 1.3% of Colombia's GDP and 12% of exports (Strambo & Velasco 2017).

The export value amounted to USD 5.3 billion, and coal is responsible for 14% of the country's export earnings, after crude petroleum which accounted for 34% of earnings in 2015 (MIT 2017). The sector is also a major recipient of foreign direct investment (FDI). The mining sector received USD 1.6 billion

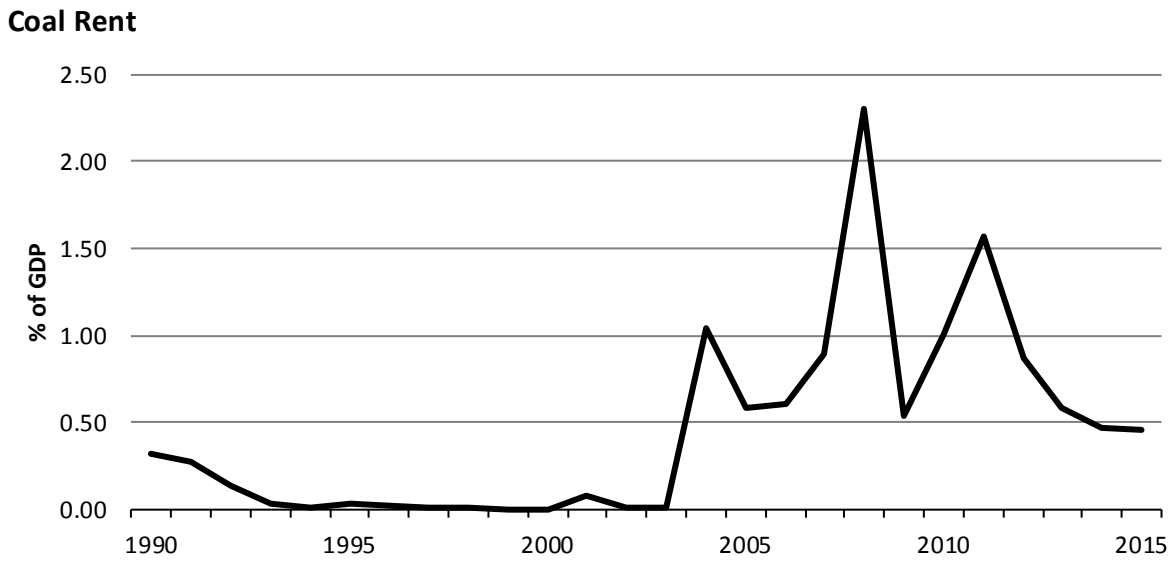
FDI in 2014 (30% of the country's total FDI) (UPME 2015). Thus, the coal industry is a key economic factor for the whole country, providing jobs and royalties for coal mining regions.

However, after steep growth rates for the last decades, coal export earnings have decreased significantly in 2015 (down from USD 7.6 billion in 2013/14) as export prices have fallen. Anthracite coal is down from USD 339/t to USD 195/t (-42%), coal briquettes down from USD 284 in 2012 to USD 123 in 2016 (-57%) and thermal coal down from USD 95/t to USD 50/t (-47%) (UPME 2016). In addition, Colombia expects coal export earnings to further decrease due to a drop in international coal demand especially from its main export partners.

While coal is slowly becoming less attractive as an export commodity, it is increasingly being directed towards domestic use. This is underpinned by the plan to ramp up coal fired power plants (see 2.8.2).

Coal rent. The relevance of coal's role for Colombia's economy can be expressed in terms of coal rent[10]: Even though coal rent values have decreased again, after peaks in 2008 and 2011 (Figure 18) coal rent in Colombia is still one of the highest in the world, at an average of 0.9% of GDP between 2005 and 2015. In comparison: coal rent values for South Africa, India, Australia are 1.33; 0.74; 0.559% of GDP in 2015 respectively (Anon 2016b).

Figure 18: Historic development of coal rent in Colombia, in % of GDP



Data source: Anon (2016b)

Employment. Coal, and the mining sector in general, also play a significant role as an employer in Colombia. Employment in the mining sector stood at 202,000 (4% of all jobs in Colombia) in 2013 (Unidad de Planeación Minero Energética 2014). Each job in the coal industry indirectly supports three to seven other jobs elsewhere (Agencia Nacional de Minera 2015) for example through off-site contractors, suppliers and subcontractors whose employment is attributable to business generated by the mining activities but also infrastructure investments (Columbia Center on Sustainable Investment 2016). Importantly, the sector generates jobs for vulnerable populations in remote areas, and coal jobs are the main economic activity in some regions (Unidad de Planeación Minero Energética 2014).

[10] Coal rent is a revenue above the costs of resources' extraction; coal rent = value of hard & brown coal production at world prices minus their total costs of production.

Royalties. Coal has brought Colombia large amounts of foreign currency. In 2015, the Colombian governments received USD 510 million in taxes and royalties from coal companies (Glencore 2017). However, royalties are not distributed equally. Critics claim that the royalty system has hampered the development and effective use of domestic industrial and human skills. As a result, Colombia has had limited opportunities to build the technological expertise in other industry sectors that is required to compete globally. The royalty distribution system was overhauled in 2012 in an attempt to boost the social benefits of royalties, but it is yet unclear whether the reforms have led to improved well-being (Strambo & Velasco 2017).

Government support. The coal export sector has traditionally received large support from the government. Tax discounts are common. In 2015, the mining sector received 23.4% of the total value of tax discounts provided to legal entities in Colombia, which reduced companies' income taxes by 11%. Between 2005 and 2010, tax breaks exceeded the amount of income taxes paid by mining companies. Even after the elimination of an expensive fiscal incentive in 2011, the effective tax rate for the coal sector was still, on average, only 66% of the nominal rate (Strambo & Velasco 2017). Direct support in form of fossil fuel subsidies however is very low (IEA 2016c), amounting to USD 268,000 (UPME 2016).

Future outlook on exported coal use

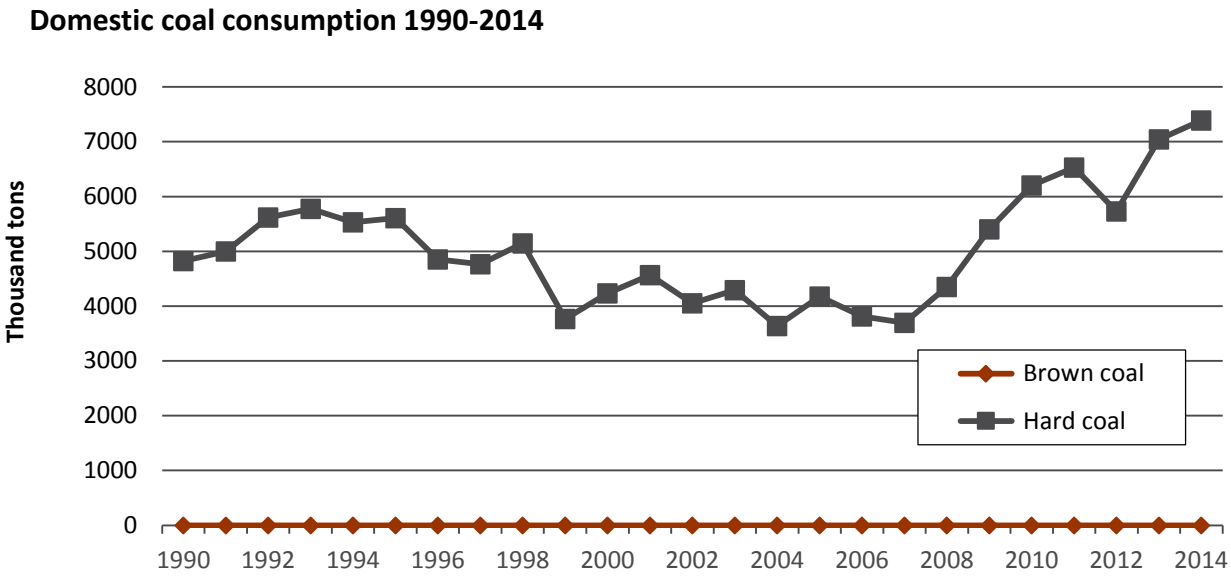
Despite estimated probable coal reserves of 5.041 Gt, with the majority of coal still in the ground, the future prospects for Colombia's coal exports are uncertain (IEA 2015). The majority of Colombian coal is sold on international markets. A combination of reduced global demand and oversupply has reduced prices. At the same time, prices for renewable energy are expected to further come down, thereby likely further decreasing the demand for coal. In addition, and closely related, air pollution is increasingly becoming a key concern for countries. China and India are already revising their planned coal capacities downwards (Climate Action Tracker 2017) and the Paris Agreement might further contribute to decreasing global coal demand as countries aim to limit global temperature increase to well below 2°C. An example is the "Powering Past Coal Alliance", a group of governments, businesses and organisations that was created in November 2017 to take action to accelerate clean growth and climate protection through the rapid phase-out of coal (Powering Past Coal Alliance 2017). Three of Colombia's main coal exporters (Netherlands, UK, Portugal) are part of that Alliance, potentially further compromising the outlook for coal exports (Powering Past Coal Alliance 2017). In addition, the forecast of global coal prices by the World Bank is as low as 50-58 USD per tonne in 2020, making the coal business even more unprofitable (Anon 2016a).

At the same time, Colombia's dependence on export earnings from coal and coal products makes it unlikely that the country will substantially limit coal extraction and exports. On the contrary, the country intends to expand its coal production further, with a planned production target of 102.5 million tonnes in 2018 (Zárate & Vidal 2016).

2.8.2 Overview of domestic coal use

Colombia extracts and consumes almost exclusively hard coal, in particular thermal coal, but also some smaller amounts of metallurgical and anthracite coal (World Energy Council 2013). Domestic consumption of hard coal, while comparatively low, has grown significantly over the last decades, increasing from 4.8 million tonnes to 7.4 million tonnes in 2014 (Figure 19). Only three percent of the country's coal production is used domestically.

Figure 19: Colombia's domestic coal consumption 1990 - 2014

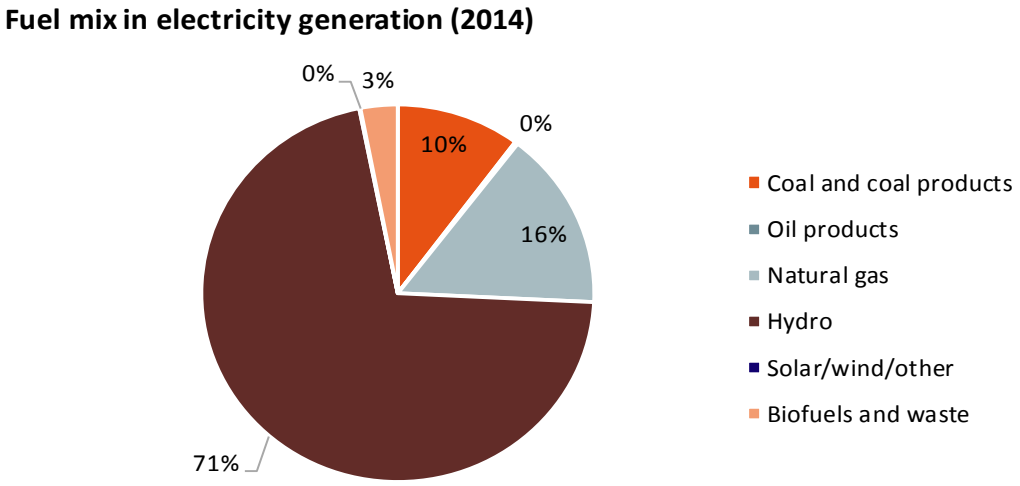


Data source: IEA World Energy Balances (2016)

The majority (35%) of Colombia's coal is used for power generation. While electricity is still largely generated by hydropower (Figure 20), coal-fired electricity capacity has been the fastest-growing technology in Colombia's electricity mix. One of the major reasons behind this increase in coal-fired electricity capacity is Colombia's objective to increase energy security. Colombia is highly dependent on hydropower for the country's electricity generation, however, due to increasingly severe and more frequent droughts this very dependence has become a challenge. In 2014, 10% or 7,100 Gwh of electricity were generated by coal and coal products (IEA 2016e).

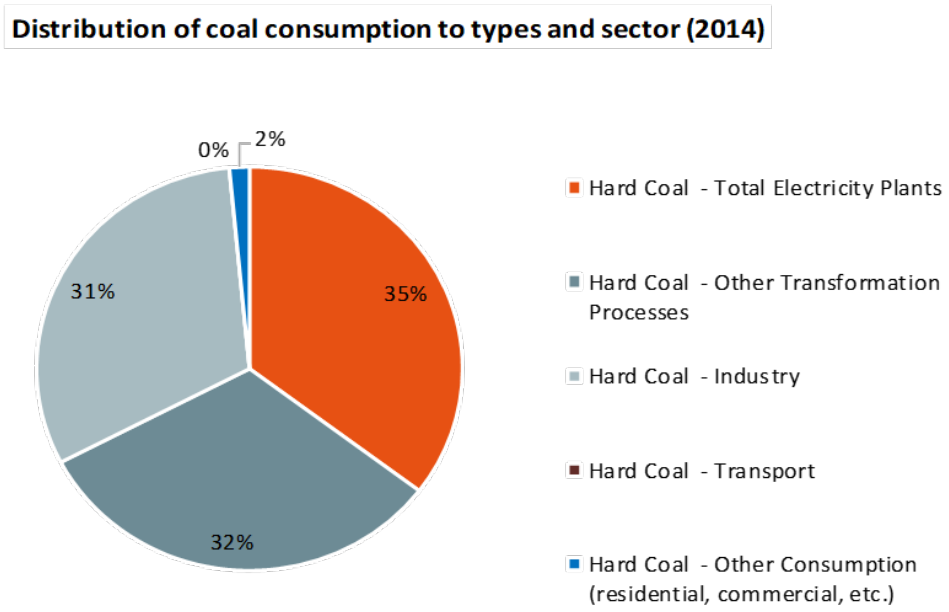
Additionally, 32% of domestic coal is used for other transformation processes and 31% is used in industry (Figure 21). Iron and steel as well as non-metallic minerals are of particular relevance in this context.

Figure 20: Colombia's fuel mix in electricity generation



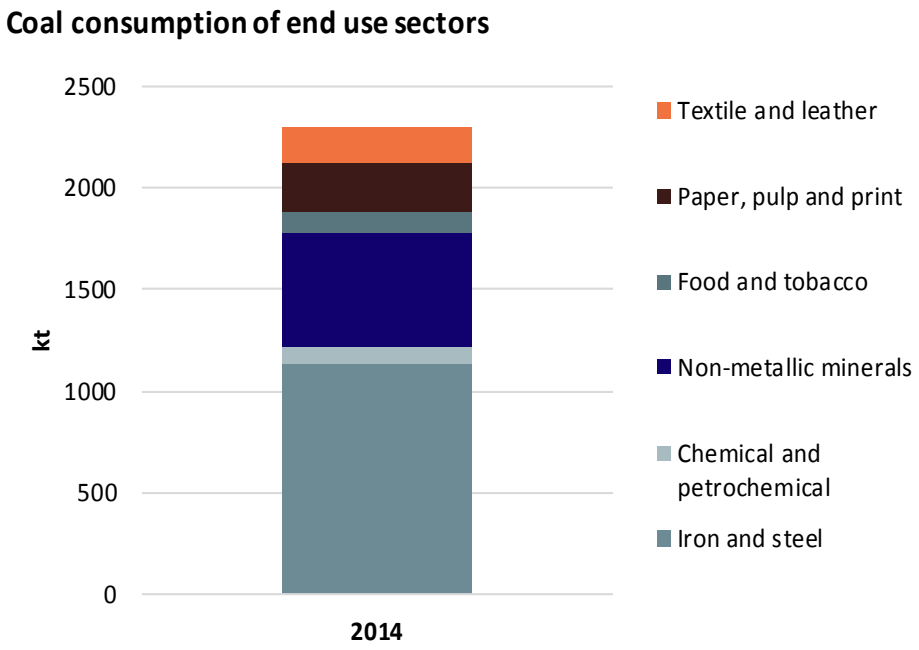
Data source: IEA World Energy Balances (2016)

Figure 21: Coal consumption by type of coal and shares of coal consumption by branch of industry



Data source: Ibid

Figure 22: Shares of coal consumption by branch of industry



Data source: Ibid

Future outlook on domestic coal use

With a view to meeting increasing electricity demand, increasing energy security and balancing decreasing profitability from coal exports (see 2.8.3), coal used for domestic electricity production has increased dramatically over the last years.

The country therefore intends to expand its coal production further, and make increasing use of coal on the domestic market to replace reliance on falling supplies of domestically produced oil and gas, as well as to further compensate for expected decreases in international coal demand and export revenues (Zárate & Vidal 2016). However, based on recent research comparing the price of renewables to the construction of new coal power plants (but not taking into account any necessary changes to the grid, for example), it seems questionable if this makes sense from an economic standpoint (Lazard 2017).

2.8.3 Local impact of coal use

Impact of power plants

The impact of power plants is largely influenced by mining governance. Mining governance in Colombia has, *de facto,* favoured the mining companies for decades. Environmental regulation was ineffectively implemented, and compliance poorly monitored, especially in the inner parts of the country. This is also due to the lack of resources by Colombian environmental agencies. Between 2010 and 2014, environmental protection agencies operated with the equivalent of 0.5% of the GDP, while the average for the Organisation for Economic Co-operation and Development (OECD) is 1.5–2% (Strambo & Velasco 2017).

Environmental impacts. Negative environmental impacts are mainly caused by open pit coal mining which affects surface and underground water. This is exacerbated by the fact that mining activities are largely concentrated in vulnerable, remote parts of the country with sensitive ecosystems (Rudas Lleras & Cabrera Leal 2015).

In addition, coal extraction has created massive amounts of waste, which in turn is impacting water resources and air quality. Air pollution is a major environmental challenge in mining regions where concentrations of particulate matter consistently exceed threshold levels set by the World Health Organisation (Ibid).

Moreover, an increasing coal production will also lead to increased GHG emissions from mining operations and also fugitive emissions from mines (existing and abandoned ones).

Human settlements. The coal industry has also led to the re-settlement of parts of the population, in particular small peasants, both voluntarily and forcefully (Strambo & Velasco 2017).

Health risks and accidents. Both coal extraction processes and its burning have highly negative impacts on local biodiversity, people's activities and health. Toxic dump water and coal dust increase the risk for numerous diseases: chemical elements and metals in mining pits' waters can cause skin diseases and skin cancer.

Coal dust in mining regions is linked to high rates of respiratory infections, in particular pneumoconiosis (Torres Rey et al. 2015). Mining accidents occur frequently due to poor safety standards and illegal operations. From 2012-15, 351 emergencies were recorded, in which 403 people died (UPME 2016).

Conflict and tensions. There is growing criticism and opposition to coal mining in Colombia for environmental and socio-economic reasons, especially for coal extraction in the inner parts of the country. During the last seven years over 50 cases have been brought to the country's Constitutional Court on the issue of mining and the involvement of the local population. In many of the court rulings,

it has overturned government legislation, allowing for greater participation and inclusion of the local population in mining related governance and projects (Strambo & Velasco 2017).

In 2017, the Constitutional Court authorised municipality councils to undertake referenda to ban mining activities in their territories. Since then, five municipalities have banned mining activities and another four municipalities have scheduled referenda to this end (Registraduria Nacional del Estado Civil 2017).

2.8.4 Coal phase out

A coal phase out is currently highly unlikely, as the analysis presented in the above sections shows. At this time, the coal debate is inextricably linked to the economic growth debate and there is no plan or goal to reduce its exportation or consumption for electricity generation.

Municipal referenda could limit the expansion of coal mining, especially in the inner parts of the country. However, due to the high level of informality of this type of production, it is likely that the ban will only affect the formal industries.

Environmental regulations could also reduce the use of coal in industrial activities to avoid stringent standards particularly in industries located in urban areas. In addition, if new gas reserves become available due off shore and fracking projects planned by Ecopetrol, Colombia's largest petroleum company, coal consumption in the industry sector could be replaced or be partially substituted by natural gas.

In the long term, it is also expected that the economy will become more orientated to technological and service activities and less dependent on the production of basic goods, with a reduction of coal consumption and exports.

At the same time, not reducing coal is likely to have a number of negative implications. These not only include negative environmental repercussions mentioned above, but importantly also mean that the government is not investing in the most cost-efficient energy technology to meet Colombia's growing energy demand but risks developing stranded assets.

2.8.5 Conclusions on coal mining and use

The coal sector is a key economic sector for Colombia. Production is at an all-time high and coal is increasingly being directed to energy production, mainly for energy security reasons. Currently, the majority of coal is exported and export earnings from coal are a major contributor to Colombia's GDP. However, international coal prices are declining, and the profitability of the coal sector is also decreasing. This trend is likely to continue. Therefore, Colombia is moving some of the coal destined for exports to its domestic consumption. Decreasing export earnings from coal coupled with a decreasing demand for coal internationally could however also provide an opportunity to diversify the country's export income. It remains to be seen if Colombia will take up these opportunities.

Coal mining has come under fire nationally, especially the informal small-scale production in the inner parts of the country where coal mining has the biggest detrimental effects on health and the environment and where mining incidents occur frequently.

Given the projected increase in coal mining and coal fired electricity capacity, emissions from the coal sector are also projected to increase. Colombia has indicated that the expected emission reductions from the currently prioritised mitigation measures by the Ministry of Energy and Mining would reduce emissions in the sector by 11.2 $MtCO_2$ by 2030 compared to 2010, mainly due to emission reductions from a shift of energy sources towards both renewables and gas for the production of energy (IDEAM 2017c). It is not clear how Colombia will meet this target if coal expansion goes ahead as planned.

Finally, a potential tension exists between recommendations for a coal phase out and the large share of coal that Germany (indirectly) imports every year from Colombia. If Germany wishes to contribute to

decreasing coal emissions in Colombia, it might be beneficial to initiate a discussion on whether and how coal imports from Colombia could be reduced.

2.9 Conclusions

Colombia has developed a comprehensive institutional set up and policy framework to implement its national climate strategy and meet its INDC target, which in turn builds on an extensive preparatory phase and analysis of mitigation potentials.

Under a current policies scenario, Colombia is likely to achieve its conditional and possibly the unconditional INDC if possible future changes to BAU projections, based on revised emissions inventory data and likely lower economic growth are considered. Rising emissions from forestry and the expansion of coal fired capacity could still compromise existing efforts.

For the effective implementation of its prioritised mitigation actions, of which most have not yet started, better alignment between different ministries and actors involved at all levels of government (national, regional, municipal) will be key, as will be the involvement of the private sector. If these mitigation actions are successfully implemented, Colombia could potentially overachieve its INDC in the future.

Additional emissions reductions can be achieved in the agriculture, forestry, housing and energy sectors. This report zooms in on various concrete examples: In the agriculture sector, emissions could be further reduced by working with the private sector towards a more sustainable supply chain, especially within the country's milk cluster. In turn, this is expected to decrease the recently rising emissions from cattle by between 6.3 to 18.5 $MtCO_2e$ by 2030.

In the forestry sector, one option for mitigation is mainstreaming forest conservation in existing illicit crop substitution programmes. Illicit crop cultivation is rising and constitutes a major driver of deforestation. Bringing together the agriculture and forestry agencies and actors and aligning their strategy on this topic could greatly contribute and reduce emissions from deforestation by around 25.1 $MtCO_2e$ or 53,579 hectares by 2030. At the same time, keeping deforestation under control is a key factor for Colombia to meet its INDC target.

Regarding the housing sector, a promising mitigation option is to extend the Green Building Code to the social housing segment to avoid the lock-in of emissions in the future. While this measure does not have a large expected impact on emissions, it carries strong co-benefits for the vulnerable parts of the population, decreasing their energy and water bills and thus contributes to efforts to lift them out of energy poverty while also increasing air quality within buildings. The construction sector as well as project developers could be involved to help ensure compliance with the Green Building Code and increase private sector buy-in.

In addition, it might be interesting for Colombia to explore a major revision of its regulatory framework on energy supply which, de facto, favours conventional energy sources. Currently both solar PV and wind only play a marginal role in Colombia's energy supply, leaving large potentials untapped. The mitigation potential from increasing renewables in the national grid is estimated at around 38 $MtCO_2e$ by 2030. Measures to tap into that potential could include the integration of demand side variables in the regulatory framework and/ or the integration of co-benefits related to increased renewable energy use to create an even level playing field for wind and solar PV. Lastly, discussions about the integration of coal into the existing carbon tax could be resumed, to internalise externalities from coal use.

3 References

Agencia Nacional de Minera, 2014. *Carbón*, Available at: https://www.anm.gov.co/sites/default/files/DocumentosAnm/carbon.pdf.

Agencia Nacional de Minera, 2015. Gobierno y empresas se unen por la minería bien hecha. Available at: https://www.anm.gov.co/?q=boletin-Gobierno-y-empresas-por-mineria-bien-hecha [Accessed January 16, 2018].

Anon, 2016a. Analysis: Sulawesi: An island of opportunity amid economic slowdown - Business. *The Jakarta Post News*.

Anon, 2016b. World Bank Database, Coal rents (% of GDP). *World Bank Database*.

Auswaertiges Amt, Kolumbien. Available at: http://www.auswaertiges-amt.de/DE/Aussenpolitik/Laender/Laenderinfos/01-Nodes_Uebersichtsseiten/Kolumbien_node.html [Accessed July 31, 2017].

BBC, 2016. Colombia's Farc rebels - 50 years of conflict. Available at: http://www.bbc.com/news/world-latin-america-36606568 [Accessed August 25, 2017].

BIOREDD USAID, 2015. Boletín Bioredd. *Sostenibilidad No 35*. Available at: http://bioredd.org/boletines-mensuales/ene-2015/.

BPIE, 2016. *Nearly zero-energy buildings. Definitions across Europe*, Brussels, Belgium: Buildings Performance Institute Europe. Available at: http://bpie.eu/uploads/lib/document/attachment/128/BPIE_factsheet_nZEB_definitions_across_Europe.pdf.

Briscoe, I. et al., 2016. *Green or grey growth for Colombia? Challenging fossil-based energy security*, Available at: https://www.clingendael.org/publication/green-or-grey-growth-colombia.

Cancilleria, *Land Frontiers*, Available at: http://www.cancilleria.gov.co/en/politica/fronteras-terrestres [Accessed July 28, 2017].

CDKN, 2016. OPINION: After Paris – A shift in Colombia's climate change conversation. Available at: https://cdkn.org/2016/04/opinion-paris-shift-colombias-climate-change-conversation/?loclang=en_gb [Accessed July 14, 2017].

Climate Action Tracker, 2017. *Action by China and India slows emissions growth, President Trump's policies likely to cause US emissions to flatten. Climate Action Tracker update. 15 May 2017.*, Climate Action Tracker (Climate Analytics, Ecofys, NewClimate Institute).

Colombian Ministry of Transport, 2016. *Exploring domestic sources of financing in Colombia Climate financing in Colombia*, Available at: https://www.thepmr.org/system/files/documents/Session 3_Sebastian_Carranza_Colombia.pdf.

Columbia Center on Sustainable Investment, 2016. Employment from Mining and Agricultural Investments. Available at: http://ccsi.columbia.edu/files/2016/07/Jobs-Paper-Aug-2.pdf.

Comision de Regulacion de Energia y Gas, 2017. Reliability Charge. Available at: http://www.creg.gov.co/cxc/english/que_es/que_es.htm [Accessed September 26, 2017].

CONPES, 2011. *Estrategia institucional para la articulación de políticas y acciones en materia de cambio climático en Colombia*, Available at: http://oab2.ambientebogota.gov.co/es/documentacion-e-investigaciones/resultado-busqueda/conpes-3700-estrategia-institucional-para-la-articulacion-de-poli-ticas-y-acciones-en-materia-de-cambio-climatico-en.

Environmental Finance, 2016. Low prices, but high hopes for the voluntary carbon market. Available at: https://www.environmental-finance.com/content/analysis/low-prices-but-high-hopes-for-the-voluntary-carbon-market.html [Accessed August 8, 2017].

FEDEGAN, 2016. *Balance y perspectivas del sector edificatorio 2016-2017*, Available at: http://camacol.co/sites/default/files/secciones_internas/Informe económico No 82.pdf.

FEDEGAN, 2017. Inventario Ganadero. Available at: http://www.fedegan.org.co/estadisticas/inventario-ganadero [Accessed November 21, 2017].

Forest Carbon Partnership Facility, 2017. *Mid-Term Progress Report Colombia*

Friedman, L., 2013. NEGOTIATIONS : New alliance attempts to bridge North-South gap in Rhetoric backed up with money â€™ A third way in Latin America '. *ClimateWire*.

Garcia, A.G. et al., 2017. *E XPORTACIONES DE CARBÓN : PERSPECTIVAS PARA C OLOMBIA EN RELACIÓN A LOS ANUNCIOS POR PARTE DE PAÍSES IMPORTADORES DE ELIMINAR EL CARBÓN DE SU MATRIZ ELÉCTRICA*, Available at: https://www.scribd.com/document/368328899/Transforma-Perspectivas-mercado-de-carbon-Colombia.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G., 2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*, Rome: Food and Agriculture Organization

of the United Nations (FAO).

GIZ, 2017. *Coca y Deforestación: Mensajes de acción para la planeación del desarrollo*, Available at: https://www.gpdpd.org/wAssets/docs/Policy_Brief_Coca-y-deforestaci-n.pdf.

Glencore, 2017. IMPACT OF BOYCOTTING COLOMBIAN COAL.

Global Coal Plant Tracker, 2017. Global Coal Plant Tracker. Available at: https://endcoal.org/wp-content/uploads/2017/07/PDFs-for-GCPT-July-2017-Countries-MW.pdf [Accessed September 26, 2017].

Gobierno de Colombia, 2015. Colombia INDC. Unofficial English Translation. Available at: http://www4.unfccc.int/submissions/INDC/Published Documents/Colombia/1/Colombia iNDC Unofficial translation Eng.pdf [Accessed July 28, 2017].

Government of Colombia, 2016. *Inventario nacional y departamental de Gases Efecto Invernadero – Colombia. Tercera Comunicación Nacional de Cambio Climático*, Available at: http://documentacion.ideam.gov.co/openbiblio/bvirtual/023634/INGEI.pdf [accessed on 23 August 2017].

Grantham Institute, 2015. *CLIMATE CHANGE LEGISLATION IN The 2015 Global Climate Legislation Study A Review of Climate Change Legislation in 99 Countries*, Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/COLOMBIA.pdf.

Green Climate Fund, 2017. Resource Mobilization. Available at: http://www.greenclimate.fund/how-we-work/resource-mobilization [Accessed August 1, 2017].

Gütschow, J. et al., 2016. The PRIMAP-hist national historical emissions time series. *Earth System Science Data*, 8(2), pp.571–603.

Höhne, N., den Elzen, M. & Escalante, D., 2014. Regional GHG reduction targets based on effort sharing: a comparison of studies. *Climate Policy*, 14(1), pp.122–147.

IDEAM, 2015. *Primer Informe Bienal De Actualización Ante La Convención Marco de las Naciones Unidas sobre el Cambio Climático*, Available at: http://unfccc.int/resource/docs/natc/colbur1.pdf.

IDEAM, 2017a. *Proyectos Sistema de Monitoreo de Bosques y Carbono*

IDEAM, 2017b. *Tasa deforestacion nacional*

IDEAM, 2017c. *Third National Communication*

IDMC, 2017. Internal displacement database. Available at: http://www.internal-displacement.org/database/ [Accessed July 28, 2017].

IEA, 2016a. *Energy Balances. 2016 edition.*, Paris, France: International Energy Agency.

IEA, 2016b. *Energy Statistics and Balances*, Paris, France.

IEA, 2016c. *Fossil Fuel Subsidy Database*, Paris, France: International Energy Agency. Available at: http://www.worldenergyoutlook.org/resources/energysubsidies/fossilfuelsubsidydatabase/ [Accessed January 25, 2016].

IEA, 2017. IEA Statistics. Colombia. Available at: https://www.iea.org/statistics/statisticssearch/report/?country=Colombia&product=indicators [Accessed August 1, 2017].

IEA, 2016d. *Key Coal Trends*, Available at: https://www.iea.org/publications/freepublications/publication/KeyCoalTrends.pdf.

IEA, 2016e. Key world energy statistics 2016. Available at: https://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf [Accessed March 31, 2017].

IEA, 2015. *World Energy Outlook 2015*, Paris, France: International Energy Agency.

Indexmundi, 2017. Colombia Economy Profile 2017. Available at: http://www.indexmundi.com/colombia/economy_profile.html [Accessed July 28, 2017].

James, C. St., 2017. Colombia's hurdles to developing a viable renewable energy sector. *Latin America Energy Review*. Available at: http://carlosstjames.com/renewable-energy/colombias-hurdles-to-developing-a-viable-renewable-energy-sector/ [Accessed September 26, 2017].

Latawiec, A.E. et al., 2014. Intensification of cattle ranching production systems: Socioeconomic and environmental synergies and risks in Brazil. *Animal*, 8(8), pp.1255–1263.

Lazard, 2017. *Levelized cost of energy v11.0*

Minambiente, 2015. *CONTRIBUCIÓN PREVISTA Y NACIONALMENTE DETERMINADA (iNDC) DE COLOMBIA*

Ministerio de Agricultura y Desarrollo Rural, 2011. *Informe de Gestión 2016*

Ministerio de Ambiente y Desarrollo Sostenible, 2016. *Decreto No. 298*, Available at: http://www.minambiente.gov.co/images/normativa/app/decretos/55-decreto 298 feb 2016.pdf.

Ministerio de Minas y Energía, 2014. *Resolución 91304 de 2014*

Ministerio de Vivienda Ciudad y Territorio, 2015. *Código de construcción sostenible en Colombia Agosto 2013 Guía de construcción sostenible para el ahorro de agua y energía en edifcaciones*

Ministerio de Vivienda Ciudad y Territorio, 2014. *Plan de Acción Sectorial de Mitigación para el Sector Vivienda y Desarrollo Territorial*

Ministry of Environment and Sustainable Development Colombia, 2016. *Post-2020 Accounting : Implications for Carbon Pricing and Registries in the Colombian*

MIT, 2017. Observatory of Economic Complexity: Colombia. Available at: http://atlas.media.mit.edu/en/profile/country/col/ [Accessed August 1, 2017].

NAMA Database, 2017. *The NAMA Database*, Available at: http://www.nama-database.org/.

ND-GAIN, 2017. Notre Dame Global Adaptation Index.

Norton Rose Fulbright, 2017. Renewable energy in Latin America: Colombia. Available at: http://www.nortonrosefulbright.com/knowledge/publications/134774/renewable-energy-in-latin-america-colombia [Accessed November 23, 2017].

PAO-YU OEI; ROMAN MENDELEVITCH, 2016. *Perspectives on Colombian Coal Exports on the International Steam Coal Market Until 2030*

Powering Past Coal Alliance, 2017. Powering Past Coal Alliance: Declaration. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/660041/powering-past-coal-alliance.pdf [Accessed January 15, 2018].

Presidencia de la República, 2017. *Acuerdo macro para la susitución Guaviare*

Proexport, 2011. *El sector Lácte en Colombia*, Bogota.

Registraduria Nacional del Estado Civil, 2017. Consultas Populares 2017 (CP 2017). Available at: www.registraduria.gov.co [Accessed September 27, 2017].

Rudas Lleras, G. & Cabrera Leal, M., 2015. *Colombia and China: Social and Environmental Impact of Trade and Foreign Direct Investment*

S&P Global Platts, 2017. Colombian thermal coal exports rise 9% in 2016 to record 88 mil mt. Available at: https://www.platts.com/latest-news/coal/london/colombian-thermal-coal-exports-rise-9-in-2016-21624989 [Accessed September 13, 2017].

Strambo, C. & Velasco, A.J.P., 2017. *The changing politics of coal extraction in Colombia*, Available at: https://www.sei-international.org/mediamanager/documents/Publications/SEI-DB-2017-The-changing-politics-of-coal.pdf.

Tafur, Oscar; Gacharna, N; Hurtado , Alexis; Zambrano, F; Murgueitio, E; Pedraza, X; Ortiz, L.H., 2011. *Leche Ambientalmente Sostenible*

The Guardian, 2016. Colombian court bans oil, gas and mining operations in paramos. Available at: https://www.theguardian.com/environment/andes-to-the-amazon/2016/feb/21/colombia-bans-oil-gas-mining-paramos [Accessed January 17, 2018].

The Guardian, 2017. Deforestation soars in Colombia after Farc rebels' demobilization. Available at: https://www.theguardian.com/world/2017/jul/11/colombia-deforestation-farc [Accessed August 29, 2017].

Torres Rey, C.H. et al., 2015. Underground coal mining: Relationship between coal dust levels and pneumoconiosis, in two regions of Colombia, 2014. *BioMed Research International*, 2015. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4558432/.

Transparency Partnership, 2017a. *Colombia*, Available at: https://www.transparency-partnership.net/country/colombia.

Transparency Partnership, 2017b. Colombia Transit-Oriented Development NAMA. Available at: https://www.transparency-

partnership.net/colombia-transit-oriented-development-nama [Accessed August 1, 2017].

UN, 2017. World Population Prospects 2017. Available at: https://esa.un.org/unpd/wpp/ [Accessed July 28, 2017].

UNDP, 2016. *Human Development Reports: Human Development Index*, Available at: http://hdr.undp.org/en/statistics/hdi/.

UNEP DTU, 2017. UNEP DTU CDM/JI Pipeline Analysis and Database: January 2016. Available at: http://www.cdmpipeline.org/ [Accessed August 1, 2017].

UNFCCC, 2017a. Submitted Biennial Update Reports Non-Annex I Countries. Available at: http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php [Accessed August 4, 2017].

UNFCCC, 2017b. Submitted National Communication from non-Annex I countries. Available at: http://unfccc.int/national_reports/non-annex_i_natcom/items/10124.php [Accessed August 4, 2017].

Unidad de Planeación Minero Energética, 2014. *Indicadores De La Minería En Colombia*, Available at: http://www.upme.gov.co/Docs/Plan_Minero/2014/Indicadores de la Minería en Colombia.pdf.

United Nations, 2014. *World Urbanisation Prospects*, Available at: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf.

United Nations, Department of Economic and Social Affairs, P.D., 2014. *World Urbanization Prospects: The 2014 Revision*,

Universidad de los Andes, 2016. *Upstream analytical work to support development of policy options for mid- and long-term mitigation objectives in Colombia*, Available at: http://www.minambiente.gov.co/images/cambioclimatico/pdf/colombia_hacia_la_COP21/Fichas_portafolio_medidas.pdf [accessed on 23 August 2017].

UNODC, 2017. Monitoreo de territorios afectados por cultivos ilicitos 2016. , p.217. Available at: http://www.unodc.org/documents/colombia/2017/julio/CENSO_2017_WEB_baja.pdf%0Ahttp://www.unodc.org/documents/crop-monitoring/Bolivia/2016_Bolivia_Informe_Monitoreo_Coca.pdf%0Ahttps://www.unodc.org/documents/crop-monitoring/Peru/Peru_monitoreo_coca_2016.pdf.

UPME, 2016. *Boletin Estadistico de Minas y Energía (2012-16)*, Available at: http://www1.upme.gov.co/PromocionSector/SeccionesInteres/Documents/Boletines/Boletin_Estadistico_2012_2016.pdf.

UPME, 2017. Colombia Energy Balance. Available at: http://www.upme.gov.co/GeneradorConsultas/Consulta_Balance.aspx?IdModulo=3 [Accessed September 13, 2017].

UPME, 2015. *Plan Energetico Nacional Colombia: Ideario Energético 2050*, Available at: http://www.upme.gov.co/Docs/PEN/PEN_IdearioEnergetico2050.pdf [accessed on 1 December 2016].

US AID, 2016. *COLOMBIA CLEAN ENERGY PROGRAM COLOMBIA CLEAN ENERGY PROGRAM Fourth Year Work Plan*,

VCS, 2018. Colombia drives innovation and carbon markets: Updated. Available at: http://www.v-c-s.org/colombia-drives-innovation-and-carbon-markets/ [Accessed January 15, 2018].

World Bank, 2015. *Ease of Doing Business Index*, Available at: http://www.doingbusiness.org/rankings.

World Bank, 2014. Understanding CO2 Emissions from the Global Energy Sector, pp.1–12.

World Bank, 2017. *World Development Indicators*, The World Bank Group.

World Energy Council, 2018. *Energy resources Colombia*, Available at: https://www.worldenergy.org/data/resources/country/colombia/gas/ [Accessed January 15, 2018].

World Energy Council, 2013. World Energy Resources: Coal. , pp.1–32. Available at: http://www.worldenergy.org/wp-content/uploads/2013/10/WER_2013_1_Coal.pdf.

World Population Review, 2017. Colombia Population 2017. Available at: http://worldpopulationreview.com/countries/colombia-population/ [Accessed July 28, 2017].

WRI, 2015. *Colombia First South American Country to Release New Climate Plan Ahead of Paris*, Available at: http://www.wri.org/blog/2015/09/colombia-first-south-american-country-release-new-climate-plan-ahead-paris.

Zárate, M.T.N. & Vidal, A.H., 2016. *Colombia Energy Investment Report*