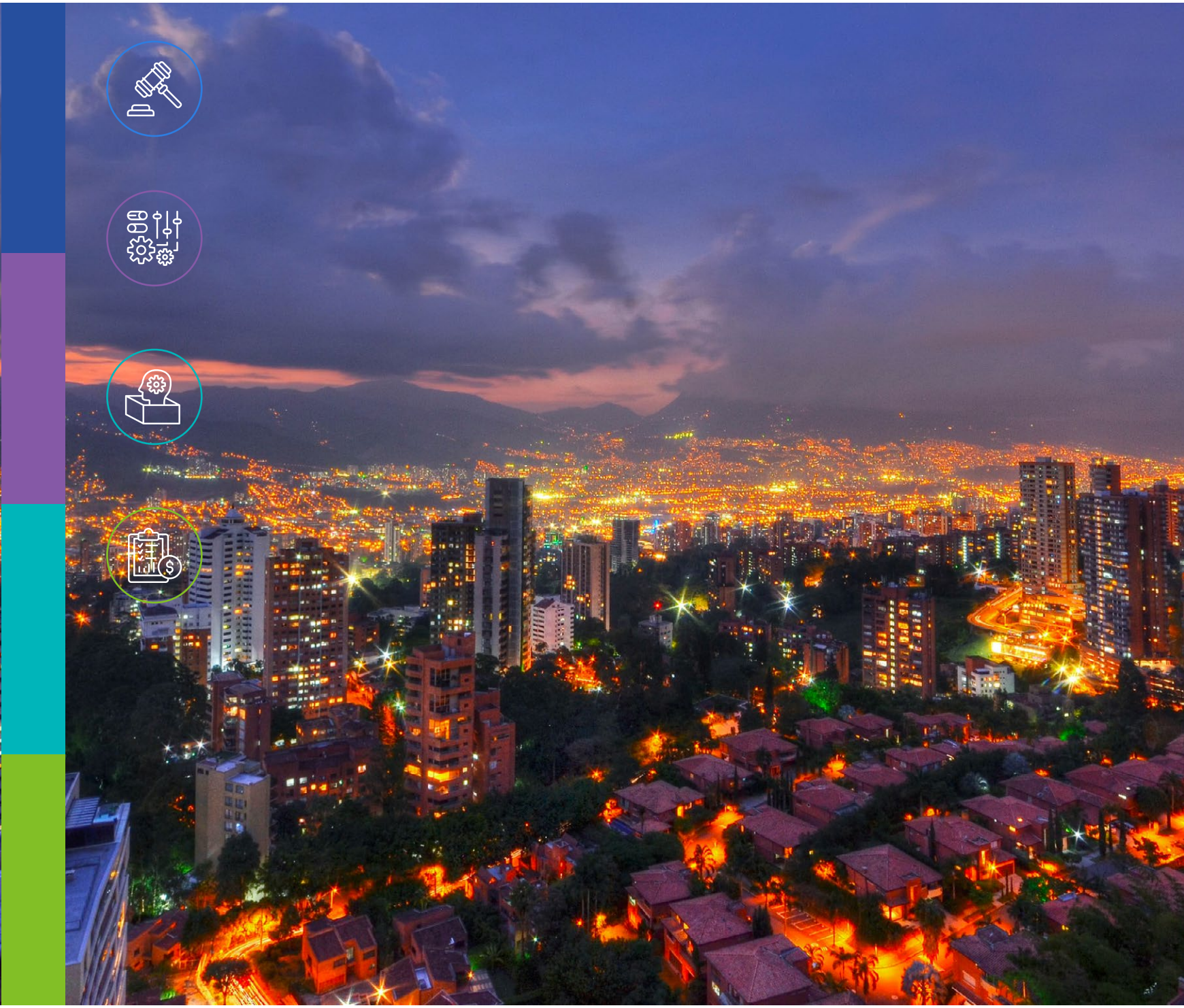
GOBIERNO DE COLOMBIA

OCTOBER 2022

NATIONAL ROADMAP FOR NET ZERO CARBON BUILDINGS



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SECTION 1: WHERE ARE WE HEADED AND WHY?

As discussed in different international forums and scenarios, the global target of keeping temperature increases below 1.5°C by the end of the century will only be achieved if GHG emissions are neutralized by 2050. Colombia, in line with global commitments, has developed a significant agenda in terms of climate change. The country is committed in the short-term with its Nationally Determined Contribution (NDC) to reduce its emissions by 51% by 2030 and to generate clear actions on adaptation. Similarly, the country has developed a long-term strategy seeking to align itself with international intentions to be carbon neutral by 2050. This strategy, called Strategy 2050 (E2050), was presented at COP-26 at the end of 2021. It includes a specific objective for the construction sector: to achieve that 100% of new and existing buildings have net zero-carbon emissions throughout their life cycle by 2050. In this context, the National Roadmap for Net Zero-Carbon Buildings was established as a sectoral instrument to outline specific goals and actions in the short (2020-2030), medium (2030-2040), and long term (2040-2050) to achieve carbon neutrality in the sector.

In Colombia, the construction sector is a fundamental driver of the economy, and it is growing rapidly. If we do not act promptly its emissions could double by 2050 (E2050, 2021). In addition, the construction of buildings has been identified as one of the sectors with the greatest influence on the reduction of emissions due to the large number of sectors that are integrated throughout its life cycle (urban development, housing, waste, industry, energy, water, and transport), and for this reason, can leverage multiple benefits in terms of equity, resilience, and health.

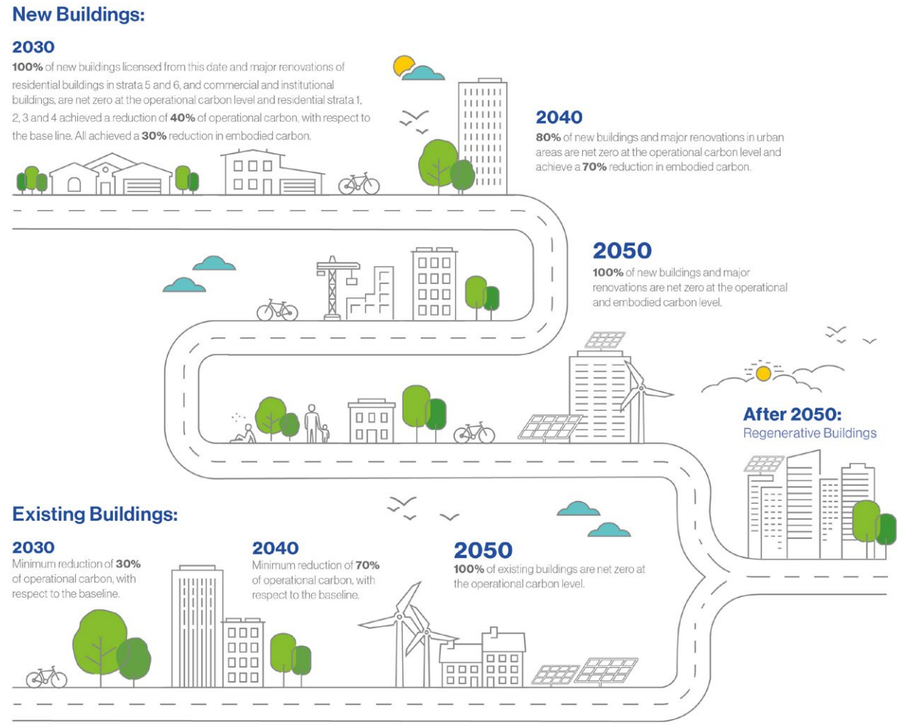
For this reason, from the Net Zero-Carbon Building Accelerator Project (AENCC, in Spanish), the national roadmap has been proposed to chart the path toward the decarbonization of this sector. This project is led by the Ministry of Environment and Sustainable Development (*Minambiente*) and its advisory committee, which is composed of the Ministry of Housing, City and Territory (*Minvivienda*), the Ministry of Mines and Energy (*Minenergia*), the National Planning Department (DNP), the cities of Bogotá and Cali, the Colombian Chamber of Construction (*CAMACOL*), and the Colombian Council for Sustainable Construction (CCCS). The project is funded by the Global Environment Facility (GEF) and is implemented globally by the World Resources Institute (WRI) and locally by the CCCS.

To establish the scope of this roadmap and the level of intervention, the advisory committee formulated a definition that integrates efficiency, resilience, well-being, a whole life cycle approach, and the interaction of a building with the environment as necessary and desirable elements of net zero-carbon buildings in the country. According to this advisory committee, in Colombia, a net zero-carbon building is:

"A net zero carbon building is a highly efficient and resilient building that, in its whole life cycle and interaction with the environment, generates well-being for its inhabitants and a net balance of carbon emissions that is equal to zero."

In addition, to build and understand the actions to be implemented in the sector to achieve net zero-carbon buildings, a national dialogue was established between the public and private sectors. For this purpose, a group of 384 experts was summoned, composed of the different stakeholders in the value chain, including the Government, the guilds, the private sector (the whole value chain), the financial sector, academia, NGOs, and cooperation organizations.

Based on the input gathered from these workshops, the understanding of the reality of the country, and based on the results of the assessment study of GHG emission mitigation measures for buildings in Colombia developed by Hill and *Uniandes* (2022)[1], this roadmap proposes general targets for operational and embodied carbon reductions between 2030 and 2040, in order to achieve net zero-carbon buildings by 2050.



Graph 1. Roadmap Goals

[1] See Assessment of GHG Emissions Mitigation Measures from Buildings in Colombia (Hill and Uniandes, 2022)

To achieve these general goals, 67 specific goals were proposed, along with transformative actions that must be taken to reach them. With this roadmap, it is now possible to determine specific objectives and identify the different stakeholders that must lead and support the development of these initiatives. This sends solid signals to the different stakeholders, both public and private, so as to begin working towards decarbonization at the different stages of the life cycle of buildings. Additionally, the roadmap groups all the actions currently being implemented by the different ministries as part of their comprehensive plans regarding climate change and other instruments, articulating them as a starting point.

SECTION 2: WHERE DO WE STAND NOW?

Baseline

According to the National Planning Department (DNP), the building sector—mainly housing— is strategic for economic growth and employment generation (*CAMACOL*, 2021). According to figures from DANE, more than one million people were employed directly in the building sector in 2021, and 2.17 indirect jobs were generated for each direct job (*Minvivienda*, 2021). In addition, in 2021, the housing market was the main investment of Colombian households and one of the major drivers of economic and social reactivation in the country (CAMACOL, 2021). Also, the country's economic growth has had an enormous influence on the construction sector and on the intensity of building activities for housing as well as for other commercial and service buildings due to the increase in the purchasing power of the population, which has enabled access to housing and to other consumption establishments.

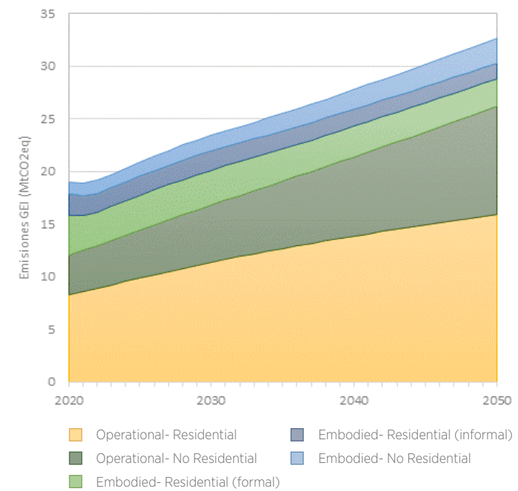
According to the National Population and Housing Census (CNPV, 2018), there are 16,070,893 housing units in Colombia. According to growth projections, between 2020 and 2050 the urban housing stock in Colombia will increase by 10.9 million. That is, of the total housing units in 2050, at least one-third will be built between 2020-2050 (*Universidad de los Andes* & Hill, 2021).

Within this growth, it should be noted that there is a major challenge in terms of housing deficit and informal construction in the country. At present, the number of households in Colombia that are considered to be informal corresponds to 1.9% of the total number of households, i.e., 236,800 (1.1% in municipal seats and 5.3% in rural areas). In addition, according to the CNPV (2018), 3.7 million households are in qualitative housing deficit, which corresponds to 26.8% of total households, while the quantitative deficit reaches a total of 9.8%. If a sufficient supply of formal housing is not generated, at the current rate of household growth and/or if forced displacement occurs due either to violence or natural disasters (related or not to climate change), the needs for housing will be met informally.

On the other hand, there were 139.2 million square meters of non-residential buildings raised in 2020. By 2050, it is projected that there will be more than 350 million square meters. In other words, this would be more than twice the existing square meters (*Universidad de los Andes* & Hill, 2021).

According to the baseline of GHG emissions from buildings in Colombia, "emissions from buildings represent close to 7% of national emissions. Excluding emissions from agriculture, forestry, and land use sectors (AFOLU), the contribution of buildings varies from 16.4% in 2020 to 11.9% in 2050. By order of magnitude, the emissions generated by buildings are comparable to those generated by the manufacturing industry." *(Universidad de los Andes* & Hill, 2021). The economic and population growth figures projected for Colombia between 2020 and 2050 will be the main drivers of the building activity. GHG emissions associated with buildings are estimated to increase from 18.9 MtCO2eq in 2020 to 32.6 MtCO2eq in 2050 (*Universidad de los Andes* & Hill, 2021). Emissions are generated mainly at the operating stage of buildings, particularly residential ones. However, embodied carbon emissions are also highly representative.

The GHG emissions baseline estimate for Colombia integrates all phases of a building's life cycle and covers the eight activities proposed by the Global Alliance for Building and Construction - Global ABC (Global ABC, 2020): materials, urban planning, new buildings, existing buildings, operation of buildings, resilience, building systems, and clean energy.



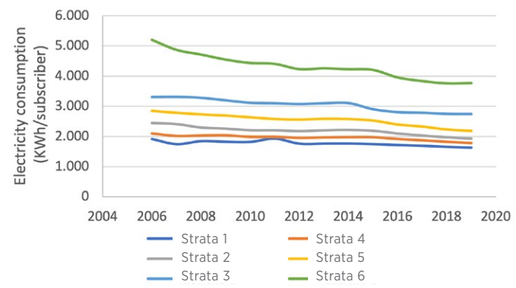
Graph 2. Projection of GHG emissions in Colombia by source type and typology under the baseline scenario (2020-2050). Source: Baseline GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.

Table 1. Categories of the life cycle of buildings and areas of intervention proposed in the framework of the AENCC project.

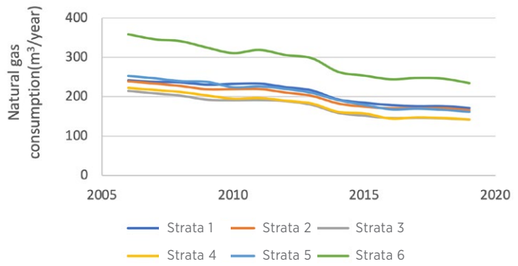
Categories in the life cycle of buildings	Use and provision of materials	Planning and design	Construction	Use and maintenance	Building systems	Clean energy
Areas of intervention	Materials	Urban planning	New buildings	Existing buildings	Appliances and other equipment and systems	Energy sources
		New buildings		Operation of buildings		

Source: Baseline of GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.

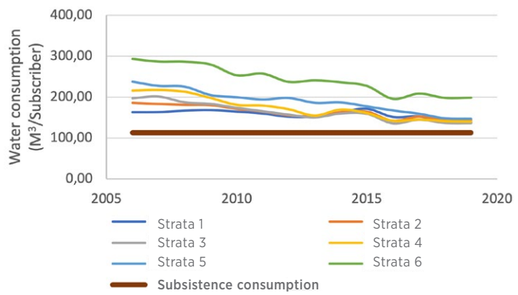
The calculation of operational emissions considered the consumption of electricity, natural gas, and water in the buildings during the operation. In the residential sector, there is generally a decreasing trend in consumption and this behavior is common to all socioeconomic levels (This is classified as "Strata", from 1 to 5 in Colombia). Electricity consumption in 2020 was between 1633 and 3764 kWh/year*subscriber; gas consumption was between 171 and 234 m3/year*subscriber, and water consumption was between 136 and 198 m3/year*subscriber.



Graph 3. National average electricity consumption per Strata. Source: Baseline GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.



Graph 4. National average natural gas consumption per household and Strata. Source: Baseline GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.



Graph 5. National average water consumption per Strata. Source: Baseline GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.

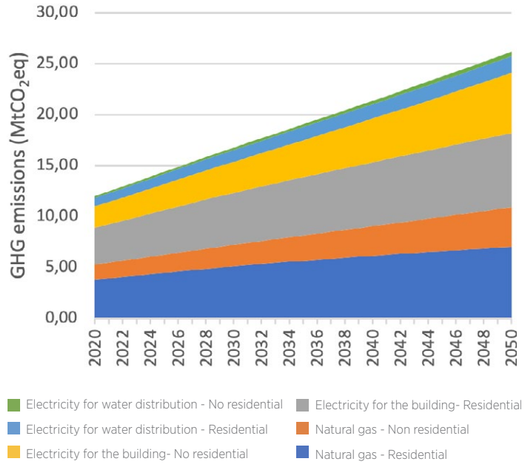
[2] The "Strata" determine whether a household gets subsidies in public services (water, energy, and gas). Strata 1 to 3 gets subsided by Strata 5 and 6. Strata [4] pays the actual value of these services.

In the non-residential sector, the following electricity, water, and gas consumption figures were identified by type of building:

Table 2. Operational Consumption in non-residential subsectors Source: Baseline GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.

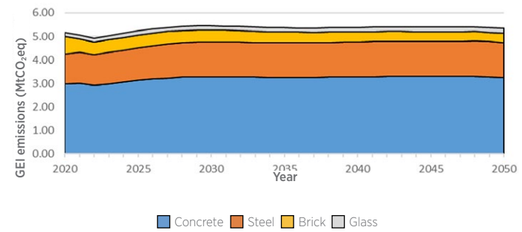
National							
Consumption	**Offices**	**Trade**	**Hotels**	**Hospital**	**Public Administration**	**Energy sources**	**Other sectors**
Electricity (kWh/month-m2)	16.50	6.65	8.50	13.05	8.51	4.34	4.69
Electricity (kWh/year-m2)	197.96	79.84	102.06	156.55	102.07	52.02	56.27
Natural gas (m3/month-m2)	0.00	0.81	0.53	0.72	0.00	0.24	0.00
Natural gas (m3/year-m2)	0.00	9.69	6.36	8.39	0.00	2.90	0.00
Water (l/day-m2)	4.73	8.51	6.78	6.78	6.78	3.63	3.63
Water (m3/year-m2)	1.73	3.10	2.48	2.48	2.48	1.33	1.33

National GHG emissions show that those associated with the use of electricity are dominant (see Graph 6). In the national residential sector, the contribution by category in 2050 is: natural gas (45.2%), electricity for the building (44.4%), and electricity for water distribution (10.4%).



Graph 6. Projection of GHG emissions associated with operation nationwide (2020-2050).

On the other hand, to calculate embodied carbon emissions, we considered the quantities of material by each type of the most common construction systems in Colombia, and the carbon coefficients of the materials. With this, we estimated the GHG emissions associated with the product stage of the buildings in Colombia. In addition, emissions associated with the consumption of energy and fuels during the construction process and the transport of materials as well as an approximation of emissions generated by repairs, replacements, and remodeling during the lifetime of the building were included.[3]



Graph 7. Projection of GHG emissions associated with the product stage in Colombia according to the type of material – baseline scenario (2020-2050). Source: Baseline of GHG emissions from buildings. Prepared by Universidad de los Andes.

This baseline of emissions provides a reference point for the assessment of different mitigation measures, from which the goals of the roadmap were set. It is important to emphasize that this was the main input for the construction of the goals, but not the only one. Targets were also integrated from the E2050, NDC 2020, the National Energy Plan, and the PIGCCS, together with adaptation and resilience targets that may not have great mitigation potential but acknowledge the importance of taking action to ensure that the sector is prepared for the changes and challenges that climate change entails, thus contributing to prosperous and resilient environments.

[3] To view in detail, please refer to the study: Baseline of GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.

Baseline assessment, gaps, and actions

In recent years, the development of sustainable real estate projects in Colombia has been enhanced due to multiple factors that have contributed to the mobilization of the market, mainly through policy and financial instruments. In addition, awareness in the sector has grown regarding the importance of minimizing the environmental impacts associated with building activity and contributing to the country's climate commitments.

To continue advancing along this path, four major enablers have been identified that could mobilize the market and civil society toward the decarbonization of the sector. These are policy, technology, capacity building, and finance. This roadmap identifies transformative actions in each of these four enablers, in all the stages of the life cycle of the buildings, to summon, encourage, and demand changes in the building sector.

Policy

The country has a favorable policy framework stemming mainly from the climate commitments made in the Paris Agreement. As mentioned at the beginning of this document, Colombia has an updated NDC by which it commits to a 51% reduction in its emissions by 2030, and the E2050 under which this roadmap is framed. At the sectoral and territorial levels, the Comprehensive Plans for the Management of Sectoral and Territorial Climate Change (PIGCCS and PIGCCT, respectively) have been established. These commitments have been ratified as enabling legislation facing climate change:

- Law 1844 of 2017: Law ratifying the Paris Agreement.
- Law 1931 of 2018: Climate Change Act, which establishes the guidelines for climate change management in the decisions by public and private persons, and the concurrence of the nation, departments, municipalities, districts, metropolitan areas, and environmental authorities.
- Law 2169 of 2021: Climate Action Act, which establishes minimum measures to achieve carbon neutrality, climate resilience, and low-carbon development in the country in the short, medium, and long term.

In addition to this, the National Government has elaborated and launched strategies and plans that are essential for the development of net zero-carbon buildings. Among them, the following stand out: the National Energy Plan 2020 – 2050 (2020); the Ministry of Mines and Energy's Transformation Mission (2019); the Roadmap for Hydrogen in Colombia (2021); the National Circular Economy Strategy (2019); the National Electric Mobility Strategy (2020); Law 1715 of 2014: Non-conventional Energy Sources; and Law 2099 of 2021: Energy Transition Law, which establishes the provisions for energy transition, the dynamization of the energy market, and the economic reactivation of the country.

On the other hand, other public policy instruments include the CONPES documents. To date, there are eight such documents that are highly relevant to the development of sustainability in the construction sector. Among them, the CONPES 3919 of 2018 "National Policy on Sustainable Buildings" stands out, which seeks to promote the inclusion of sustainability criteria for all uses and within all stages of the life cycle of buildings. However, this instrument focuses only on new buildings.

There are also mandatory regulations that promote sustainability in construction. Among these, Resolution 549 of 2015 by the Ministry of Housing, City, and Territory stands out, which determines the minimum percentages and measures of water and energy savings to be achieved in new buildings, constituting the first step towards highly efficient buildings. Also, Minambiente's Resolution 1257 of 2021 (which updates Resolution 472 of 2017) on the management of Construction and demolition waste (CDW). Although these regulations exist, there is no effective monitoring system to guarantee their application in the national territory, which is something essential to be solved in the short term.

The main regulatory advances and incentives that currently exist in the country are focused on energy efficiency measures, the use of clean energy, and the decarbonization of the energy matrix. However, there are still some barriers in regulation and accessibility to technologies that need to be solved in the coming years to achieve the massive implementation of clean energy and energy efficiency measures in all buildings.

The main policy gaps have to do with embodied carbon issues and existing buildings. Currently, there is no regulation or incentive that considers sustainability aspects regarding materials or embodied carbon limits in buildings, nor are there regulations or incentives to promote water and energy savings in existing buildings or retrofits. It is necessary and urgent to develop policy instruments and incentives to address these aspects.

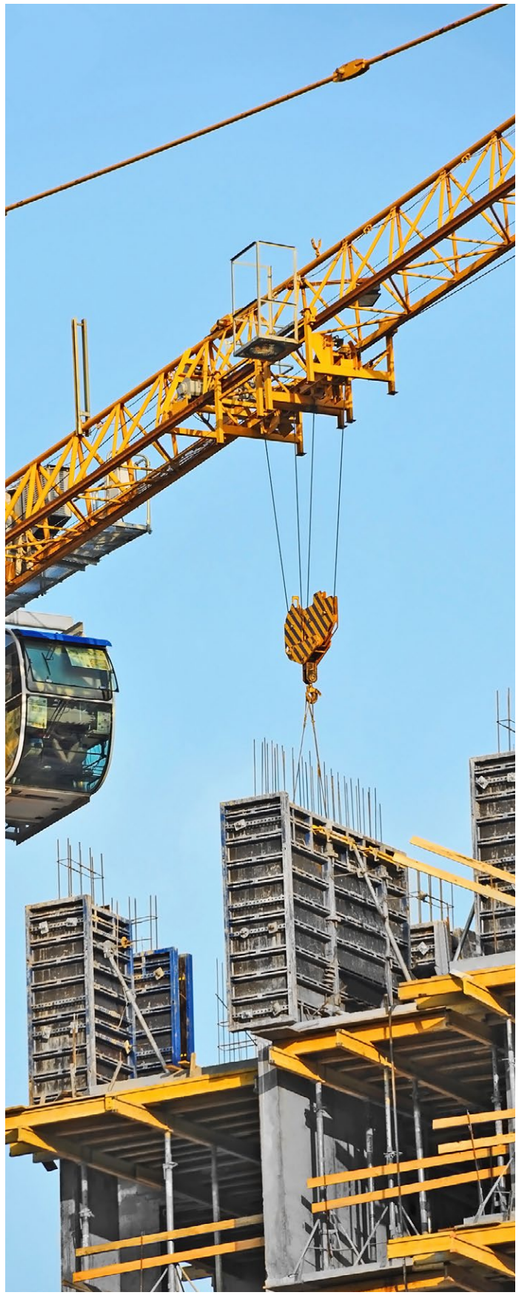
Technology

From the point of view of technological transformation, there are important challenges, as Colombia is mainly an importer of technology. For this reason, it is necessary to work not only from the perspective of the resources needed to bring better technology, but also regarding the development of local research and innovation in order to develop efficient and accessible technology for all.

According to the BEU (Useful Energy Balance) presented by UPME in 2018, in general terms, the different sectors that make up the construction value chain use inefficient technology, far below the best technology available internationally. This includes the processes for extraction and manufacturing of materials, construction processes, and building and appliance systems, which means that a significant technological leap must be taken to achieve high levels of energy efficiency in production processes as well as for the operation of the buildings.

Energy efficiency programs have stemmed from the policy addressed at the industry of materials to promote technological conversion in this sector. While these projects have taken important steps, major technological innovations are required to enable industrial-scale production of low- or zero-carbon embodied materials. These innovations must develop around the replacement of fossil fuels, carbon capture and storage, process electrification, use of hydrogen, reduction in the use of non-renewable raw materials, and the integration of nanotechnology into products, among others. Many of these technologies are still under development around the world, which means that Colombia must strive not to be left behind in terms of development and innovation.

Regarding design and construction processes, the sector is generally underdeveloped technology-wise. There is much informality and little investment is made in the planning and design of projects, leading to inefficiencies, reprocesses, and waste generation. As for construction systems, light and modular construction systems are scarcely used, and in general, there is very little research and development



regarding alternative structural systems. As for construction processes, there has not been a great advance in the technification of the processes, and there is low utilization of CDW (construction and demolition waste).

From the standpoint of the use of renewable energies, an increasing trend of projects registered in the national interconnected energy system that uses energy such as wind, solar, and biomass has been identified since 2015 (CCCS, 2021). In addition, the long-term auctions, the issuance of CREG Resolution 030, and thermal district projects that promote decarbonization and decentralization of energy, together with the incentives of Law 1715, stand out (Ferro, 2021).

In general, there is little data and information for measuring and reporting greenhouse gas emissions and energy consumption. It is necessary to develop and implement technology to enable advanced measurement, as well as software and hardware for data processing and devices to allow widespread use of demand response and embodied carbon calculation systems. Without this information, it is not possible to generate indicators and targets, nor to monitor and assess policy effectiveness.

Capacity building

Qualified personnel are essential to develop sustainable buildings. Currently, some universities have integrated subjects related to sustainable construction into their curricula, and some have even developed specialization and master's programs in this area (CCCS, 2021).

In 2020, Mineducación and CAMACOL designed the qualifications for the construction sector according to the national qualifications framework, which includes competencies associated with work on sustainable construction projects. An important topic included is the training in separation at source for adequate management of CDW as one of the actions to promote circularity.

It should also be noted that Minvivienda and CAMACOL have developed training courses aimed at digitalizing the sector in the use of BIM methodology and tools, within the framework of the BIM Forum Colombia, to which

manufacturers, builders, designers, and academia have been integrated. In 2021, the CCCS provided more than 9,000 man-hours of training for value-chain professionals interested in improving their skills in sustainable construction.

However, there are still large gaps in capacity development. Although sustainability has been integrated as a subject in different careers related to the construction value chain, it has not permeated curricula in a cross-cutting way. In addition, there are not many research groups on sustainable construction, sustainable materials, energy efficiency, etc. Also, there is no strong articulation between research programs and industry, which makes it difficult to massify different innovations and technologies. Finally, there is a need for greater penetration of sustainability in elementary and higher education. This would drive a transformation of the market from a more aware and demanding user.

Finance

The financial sector and the development of incentives and subsidies by the government have mobilized sustainable construction in the country. Climate finance currently plays an important role in Colombia, and this is seen in the various initiatives, investments, and financial services generated in recent years.

Colombia has issued Green Corporate Finance Bonds, Certified Climate Bonds, and a Sovereign Bond, thus becoming one of the leading South American countries in issuing such bonds (CCCS, 2021). The energy sector has been the main recipient of climate investment resources. Nevertheless, unlike other Latin American countries, the construction sector in Colombia has been the second major recipient.

The movement of resources to promote the development of sustainable construction projects began in 2016 with a bond issued by Bancolombia. Since then, other organizations such as Bancoldex, Davivienda, Celsia, ISA, and the Banco de Bogotá have also done so. These resources have enabled the deployment of financial services such as credit lines aimed at purchasing and constructing sustainable projects. From the insurance sector, Seguros SURA currently offers benefits for projects that have a green building certification, thus reducing the premia in compliance and construction insurance policies and extending the benefits to the buyer, who can access a discounted lease or home insurance policy.

On the other hand, the government has the Findeter reactive line for sustainable VIS housing that meets specific sustainability criteria based on Resolution 549 of 2015. While this credit line offers a very attractive rate, it has not been widely used in the country because of a lack of clarity in its access criteria.

In addition, the government generated a series of tax incentives derived from the Tax Statute and Law 1715 of 2014 for energy efficiency projects as well as equipment, technologies, and services that offer environmental benefits. Benefits include VAT exclusion, income discounts and deductions, duty exemption, and accelerated depreciation. In sustainable construction projects, there are some components, materials, and additional elements of passive measures. These VAT and income benefits can be accessed only if the building has been certified as a sustainable construction. Likewise, these types of projects can access the income benefit in architectural design and engineering services. The procedure to access these benefits is regulated by Resolution 196 of 2020.

Recently, the government also generated a grant called "Ecobertura" for non-VIS housing projects built under certified sustainability standards as part of the economic recovery package. The coverage is equivalent to a monthly subsidy for the payment of interests on the mortgage loan or lease and is up to 52 current statutory minimum monthly wages (SMMLV), i.e., 10 SMMLV more than the FRENCH NO VIS subsidy. This is an important instrument to mobilize the market from the demand side.

Finally, it is important to mention that the Office of the Financial Superintendent recently published the green taxonomy as the main instrument to guide the investments made in sustainability in the country. This taxonomy includes definitions for sustainable buildings, construction, and materials, thus opening many possibilities for this sector. It is worth noting that there is a high interest by commercial banks in developing new products aimed at promoting investment in sustainability. This framework is essential for this purpose.

Stakeholders and institutional arrangements

Achieving net zero carbon buildings in Colombia requires a significant commitment from the public and private sectors, integrating the entire value chain of the building industry. Regarding the public sector, the leadership by *Minvivienda*, *Minenergia*, and *MinCIT* is necessary nationwide, as they are the main sectors that impact the life cycle of building activities. Additionally, a strong leadership is required from Minambiente and the DNP regarding State policies. It is recommended that each of these institutions integrate the goals proposed in this roadmap to achieve net zero carbon buildings into their planning instruments. Similarly, the participation of other ministries and entities including *Minhacienda, Minciencias, Mineducación, Mintransporte, IDEAM, and ICONTEC* is important. As part of this roadmap, they are responsible for the implementation of specific transformative actions.

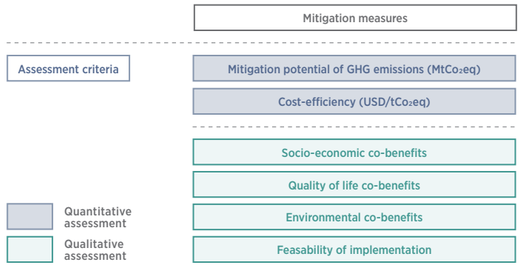
On the other hand, it is evident that achieving the goals requires strong intervention from local governments, who are recommended to develop a specific action plan that focuses on local needs and realities. As part of their development and implementation, the participation of different local entities such as chambers of commerce is very important to move forward faster.

On the other hand, the private sector must make a strong commitment from the entire value chain, integrating the processes for the supply of materials and components, cargo transport, and use of yellow machinery, design and construction practices, operation and maintenance practices, and deconstruction practices, with participation from cross-cutting sectors such as energy generation and the financial sector. For this, it is necessary that different guilds and associations of the sector, among them, the *Sociedad Colombiana de Arquitectos, Sociedad Colombiana de Ingenieros, Asociación Colombiana de Ingeniería Estructural, CAMACOL, Procemco*, the committees from ceramics, shipyard, and steel producers from *ANDI, Asobancaria, Acolvise, Acoplásticos*, and the CCCS, exercise a significant leadership. It is recommended that each of these organizations develops a specific action plan that will enable subsectors to generate the necessary transformations. Similarly, the commitment and leadership of all the companies within the value chain are critical. Therefore, it is recommended that these organizations establish a roadmap for their own business.

Finally, to achieve the goals proposed, participation by the academia as well as research and training institutions is essential. Significant changes must be made in the way in which disciplines related to the value chain are taught, and specific skills must be achieved by graduates in line with the transformative actions proposed and for which this sector is responsible.

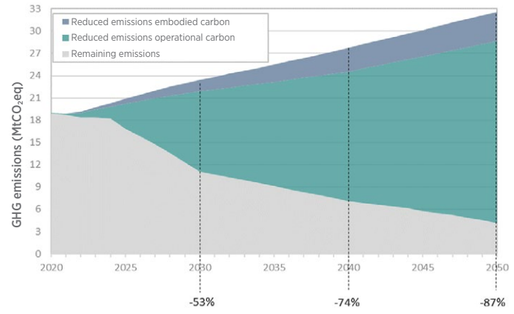
Estimated impacts

The methodology used to assess mitigation measures is based on previous national studies as well as international references, considering both quantitative and qualitative criteria. Twenty-five mitigation actions were selected to evaluate six criteria: mitigation potential; costs; socio-economic, environmental, and quality-of-life co-benefits; and feasibility of implementation.



Graph 8. Multi-criteria analysis for GHG emission mitigation measures. Source: Assessment of GHG Emissions Mitigation Measures from Buildings in Colombia. Prepared by Universidad de los Andes and Hill consulting, 2022.

The assessment of mitigation actions resulted in the prioritization of actions and the formation of different portfolios to meet the general goals for 2030, 2040, and 2050. Based on them, a maximum mitigation scenario is proposed:



Graph 9. Reduced GHG emissions with the operational and embodied carbon portfolio. Source: Assessment of GHG Emissions Mitigation Measures from Buildings in Colombia. Prepared by Universidad de los Andes and Hill consulting, 2022.

Based on the maximum mitigation scenario proposed by Hill and *Uniandes* (2022)[4], with the goals and actions proposed by this roadmap, the country is close to achieving net zero-carbon operational buildings by integrating offsets with a relatively low intensity. A mitigation rate of close to 95% would be achieved prior to compensations.

Table 3. Comparison between mitigation achieved with the portfolio and the goals of the AENCC project regarding operational carbon.

Year	Segment	Mitigation Goal	Baseline of annual emissions (MtCO2eq)	Annual emissions target (MtCO2eq)	Annual emissions with mitigation portfolio (MtCO2eq)	Percentage achieved in mitigation	Residual emissions (MtCO2eq)
2030	New buildings and major renovations - strata 5 and 6	100%	0.87	0	0.06	93%	0.06
	New buildings and major renovations - commercial and institutional	100%	1.96	0	0.39	80%	0.39
	New buildings and major renovations - Residential VIS and VIP + strata 3 and 4	40%	2.90	1.16	0.92	68%	0
	Existing buildings	30%	11.07	7.75	5.20	47%	0
2040	New buildings	80%	10.86	2.17	1.61	85%	0
	Existing buildings	70%	10.53	3.16	2.35	78%	0
2050	New and existing buildings	100%	26.23	0	1.68	94%	1.68

[3] To view in detail, please refer to the study: Baseline of GHG emissions from buildings. Prepared by Universidad de los Andes and Hill consulting, 2021.

On the other hand, based on the maximum mitigation scenario studied and according to the information and technology available at this time, the goals and actions proposed in this roadmap take some important steps toward the mitigation of embodied carbon. However, there is a significant gap from the proposed decarbonization target, considering that an emission reduction rate of close to 55% could be achieved. This would require the incorporation of a significant level of compensations to achieve carbon neutrality.

Table 4. Comparison between mitigation achieved with the portfolio and the goals of the AENCC project regarding embodied carbon.

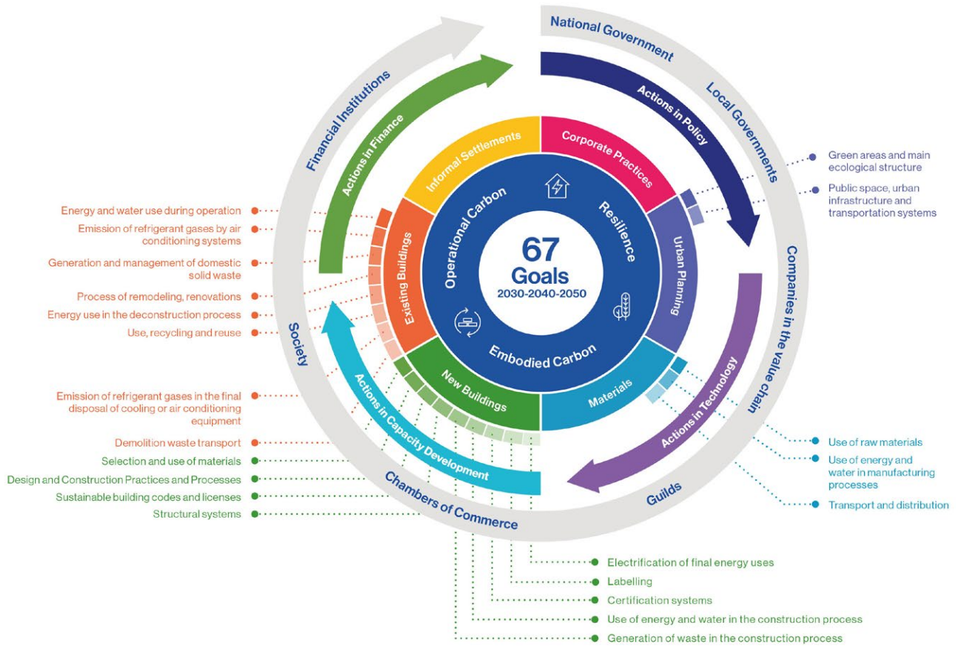
Year	Segment	Mitigation Goal	Baseline of annual emissions (MtCO2eq)	Annual emissions target (MtCO2eq)	Annual emissions with mitigation portfolio (MtCO2eq)	Percentage achieved in mitigation	Residual emissions (MtCO2eq)
2030	New buildings, infrastructure works, and renovations	30%	6.60	4.62	4.87	26%	0.26
2040	New buildings, infrastructure works, and renovations	70%	6.37	1.91	3.44	46%	1.53
2050	New buildings, infrastructure works, and renovations	100%	6.36	0	2.96	53%	2.96

Source: Assessment of GHG Emissions Mitigation Measures from Buildings in Colombia. Prepared by Universidad de los Andes and Hill consulting, 2022

SECTION 3: HOW DO WE GET THERE?

The roadmap is structured into six categories of action: corporate practices, urban planning, materials, new buildings, existing buildings, and informal settlements. Each of these categories, except for corporate practices and informal settlements, is divided into subcategories that allow the goals to be grouped according to the associated emissions and the transformative actions to be carried out. For each sub-category there are one or more specific targets with thresholds that must be reached in 2030, 2040 and 2050 in order to achieve the major targets proposed by this roadmap. Each goal includes the main stakeholders that should be involved in the implementation, achievement, and follow-up of the intended goal. Also, the effect sought with the target is also indicated, whether it is operational carbon mitigation, embodied carbon mitigation, and/or resilience.

In addition, for each of the action subcategories, the transformative actions that must be implemented at the national level are presented to achieve the goals within the framework of the four enablers: policy, technology, capacity development, and finance.



Graph 10. Structure of the Roadmap

Corporate Practices

The category for **corporate practices** establishes a single goal for companies in the construction sector's value chain to achieve decarbonization. To this effect, actions focused on encouraging the design and implementation of decarbonization plans and the development of capacities within companies must be generated, enabling them to formulate and implement these plans as well as to measure and manage their carbon footprint.

Table 5. Goals. Corporate practices

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon Embodied carbon Resilience	The companies in the construction sector value chain have developed their carbon footprint calculation and roadmap to decarbonization, including scopes 1, 2 and 3.	The companies in the construction sector value chain have implemented their roadmaps toward decarbonization	The companies in the construction sector value chain have achieved decarbonization.	• MinCIT • Minenergía • Minvivienda • Minambiente • Chambers of Commerce • Private companies • Guilds of each industry • Academia • Local governments

Urban Planning

The goals pertaining to the category for **urban planning** are oriented toward mitigation and adaptation actions from urban settings and are divided into two emission subcategories, which are: (i) green areas and main ecological structure, and (ii) public space, urban infrastructure, and transportation systems. In the first subcategory, three goals were generated aimed at the protection, restoration, and increase of the main ecological structure and green coverage. To achieve this, different actions were identified to generate better interaction and definition of intersectoral and intergovernmental channels. Also, guidelines were included for sustainable urban planning and infrastructure based on nature from the tools for territorial planning and by involving civil society in risk management and adaptation to climate change.

Table 6. Goals. Green areas and main ecological structure.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon Resilience	The criteria for land use have been developed to: protect ecological structures; recover remaining ecosystems; increase ecological connectivity (structural and functional) of different types of ecosystems and urban plant cover (e.g. forests, wetlands, parks); and reduce environmental degradation.	Sixty percent of the strategic ecosystems of the cities prioritized by E2050 are undergoing restoration, rehabilitation, and recovery, seeking to address the reduction of disaster risks in the face of hydro-meteorological hazards and contribute to carbon fixation by designing specific measures caring for women and children.	One hundred of the strategic ecosystems of the cities prioritized by E2050 are undergoing restoration, rehabilitation, and recovery, seeking to address the reduction of disaster risks in the face of hydro-meteorological hazards and contribute to carbon fixation by designing specific measures caring for women and children.	• Minambiente • Minvivienda • CAR • UNGRD • IGAC • IDEAM • DNP • Environment Secretariats • Planning Secretariats • Civil society
Operational carbon Resilience	The territorial planning plans (POT) have been updated with the effective and substantive participation of women in decision-making scenarios to protect the main ecological structure, increase the quantity and quality of urban and peri-urban plant cover with social and ecological functionality, and integrate climate risk management. Tree coverage and the potential for an increased urban forest coverage that contributes to the CO2 harvest and the decrease in the incidence of respiratory diseases has been estimated at 100% in special category municipalities, 50% in category 1 municipalities, and 50% in category 2 municipalities below 1,600 masl.	The Land Use Planning Plans (POT) and Basic Land Use Plans (PBOT) have been updated with effective and substantive participation of women in decision-making scenarios to protect the main ecological structure, increase the quantity and quality of urban and peri-urban plant cover with social and ecological functionality, and integrate climate risk management. Ten square meters of green area per inhabitant have been achieved in 100% of the municipalities of special category and in 50% of category 1 below 1,600 masl.	The socio-ecological functionality is the structuring element of territorial planning and conditioning of urban development for the reduction of risk due to climate change and for damage/losses in vital urban infrastructure and the supply of public utilities. Ten square meters of green area per inhabitant have been achieved in 100% of the municipalities of special category and in 100% of category 1, and 50% of category 2 below 1,600 masl.	• Minambiente • Minvivienda • CAR • UNGRD • IGAC • IDEAM • DNP • Environment Secretariats • Planning Secretariats • Public utilities companies • Private sector • Civil society
Operational carbon Resilience	Guidelines and regulations have been developed to meet the requirements of area, ecological connectivity, and quality of green infrastructure in urbanization and public space development processes.	The area, ecological connectivity and quality of green infrastructure required in the processes of urbanization and public space development has increased. The quality of green infrastructure is understood as that which provides some environmental, social, and cultural service: recharge of aquifers sustainable drainage, reduction of heat islands, capture and storage of GHGs, etc.	In all cities, the quantity, quality, and functionality of public and private green infrastructure has increased, integrating a gender approach to promote eco-systemic services related to GHG capture, water regulation, erosion control, and micro-climatic regulation, among others, which are key to adaptation and risk reduction.	• Minambiente • Minvivienda • CAR • UNGRD • IGAC • IDEAM • DNP • Environment Secretariats • Planning Secretariats • Civil society

Public Space, Urban Infrastructure, and Transport Systems

In the second sub-category for **public space, urban infrastructure, and transport systems**, seven goals are proposed to increase the resilience of the infrastructure; to implement the infrastructure for sustainable air conditioning, generation of clean energy, water management, and efficient lighting; and to generate guidelines from territorial planning for a transportation-oriented development plan. To this end, the proposal includes encouraging diverse urban sources of clean and decentralized energy; integrating considerations of compact urban growth in urban planning; including guidelines from land use tools focused on increasing resilience; and promoting the development of low-carbon infrastructure.

The effective implementation of the proposed actions in the entire urban planning category requires the training of urban planners and designers, as well as the development of financial mechanisms that make sustainable urban development viable and the implementation and development of the necessary technology.

Table 7. Public space, urban infrastructure, and transportation systems.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon Resilience	Damage to vital infrastructure and infrastructure associated with energy and water has been reduced by 40% to 60% through the implementation of adaptation measures based on the balance between green and gray infrastructure in urban and peri-urban areas.	Damage to vital infrastructure and infrastructure associated with energy and water has been reduced by 60% to 80% through the implementation of adaptation measures based on the balance between green and gray infrastructure in urban and peri-urban areas.	Damage to vital infrastructure and infrastructure associated with energy and water has been reduced by 80% to 90% through the implementation of adaptation measures based on the balance between green and gray infrastructure in urban and peri-urban areas.	• Minambiente • Minenergía • Minvivienda • DNP • CAR • CRA • Local governments
Operational carbon Resilience	Thermal districts have been developed in eight (8) cities, five (5) in major cities, and three (3) in intermediate cities. Territorial planning plans (POT) and territory management instruments allow to sectorize and creation of zonal units that share services and functionalities to enable the development of thermal districts and other air conditioning solutions and/or sustainable energy generation (energy districts).	In 70 to 90% of the cities, thermal districts, or other solutions for climate control and/or sustainable energy generation (energy districts) have been implemented.	Thermal districts or other climate control and/or sustainable energy generation solutions (energy districts) have been implemented in 100% of the cities.	• Minambiente • Minenergía • Minvivienda • UTO • UPME • CREG • IDECA • Public utility companies • Private sector • Financial institutions • CIDARE
Operational carbon Resilience	A regulation has been developed for new buildings and urban projects to include SUDS.	Regulatory requirements for the generation of SUDS in urban environments are increased progressively.		• Minambiente • Minvivienda • CAR • DNP • CRA • Public utility companies • Private sector • Guilds and associations
Operational carbon Resilience	The use of LED lighting technologies, solar photovoltaic lighting, and remote management systems in public lighting systems has increased.	There is the widespread use of LED (or the best available) technology, solar photovoltaic lighting, and remote management systems in public lighting systems	All public lighting systems use LED (or the best available) technology, solar photovoltaic lighting, and remote management systems.	• Minenergía • Minvivienda • UPME • Local governments • Public utility companies • Private sector: Manufacturers or suppliers of new technologies and developers
Operational carbon	The POT, Master Plans, and District and Municipal Development Plans have integrated dimensions for transport-oriented development to increase the participation of active and shared means of transportation (including mass and collective public transport) and micro-mobility. Including actions to improve access for women: Use of public services and spaces without limitations or barriers, and with proposals for safe, easy, and affordable mobility.	Projects to revitalize the city and develop new areas use a transportation-oriented development approach to achieve a 60% participation rate of active and shared means of transportation (including mass and public transport) and micro-mobility and VKT reduction (mile traveled per vehicle) in private vehicles.	Projects to revitalize the city and develop new areas use a transportation-oriented development approach to achieve a 70% participation rate of active and shared means of transportation (including mass and public transport) and micro-mobility and VKT reduction (mile traveled per vehicle) in private vehicles.	• Minvivienda • Minambiente • Mintransporte • DNP • Secretariats and planning departments • Guilds and associations • Private sector • Civil society

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	Ninety percent of priority housing projects co-financed by the State have connectivity to urban transport systems or sustainable transport networks.	One hundred percent of priority housing projects that are co-financed by the State and 60% of low-income housing projects have connectivity to urban transport systems or sustainable transport networks.	One hundred percent of priority housing projects that are co-financed by the State and 100% of low-income housing projects have connectivity to urban transport systems or sustainable transport networks.	• Minvivienda • Minambiente • Mintransporte • DNP • Secretariats and planning departments • Guilds and associations • Private sector • Civil society
Embodied carbon Resilience	Urban infrastructure, including transport, uses low-carbon materials with other sustainability attributes (such as permeability and drainage, among others) to reduce damage and losses due to climate change and extreme weather events.			• Minambiente • MinCIT • Local governments • Guilds associated with the main manufacturers • Normalization • Private sector • Builders, consultants, and designers

Materials

The goals and actions of the category of **materials** are aimed at reducing emissions in the processes of raw material extraction, manufacturing, and transportation of materials. The goals are divided into three emission subcategories: (i) use of raw materials, (ii) use of energy and water in the manufacturing process, and (iii) transportation and distribution.

In the first subcategory, Use of Raw Material, eight targets were established that focus on the reduction of the demand for virgin raw material, the implementation of strategies for energy efficiency, less carbon-intensive practices during the extraction process, and stimulating markets for low-carbon, recycled-content products, and materials. Among the main actions proposed are the use of the LCA both for construction projects and for materials; prioritization of rehabilitation or readaptation of existing buildings; integration of requirements for sustainable materials in building codes; development of standards for yellow machinery; and development and research of recycled and low carbon materials, among others.

Table 8. Use of Raw Material.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	From the remodeling of existing buildings, the extraction of virgin raw materials has been reduced.	The number of buildings planned to be demolished is reduced by 50% due to the remodeling of existing buildings.	N.A.	• Minvivienda • Minambiente • Local entities • Construction companies • Academia
Embodied carbon	Incorporation of raw materials used in construction progressively increases to reduce the extraction of virgin raw materials.			• Minambiente • Minvivienda • MinCIT • Minenergía • Guilds associated with the main manufacturers • Companies manufacturing materials • ICONTEC • Academia

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	The cement-clinker factor has been reduced to a 68% proportion.	The cement-clinker factor has been reduced by 7.3%, reaching a 63% proportion.	The cement-clinker factor has been reduced by 10%, reaching a 58% proportion.	• MinCIT • Procemco • Minambiente • Cement industry
Embodied carbon	The use of lagging materials in terms of reuse/recycling has increased: glass, wood.	The following harvest rates have been achieved: 40% plastics, 30-40% glass, 30-40% wood.	The following harvest rates have been achieved: 50% concrete, 60% plastics, 90% steel, 40-50% glass, 40-50% wood.	• Minambiente • Minvivienda • MinCIT • Local governments and local environmental authorities • Recyclers' guilds and recycling associations • Construction companies • Managers • Civil society • Academia
Embodied carbon	The use of yellow machinery has been regulated in the country, so the machinery used in the extraction of raw materials for construction has minimum Tier 4 Interim or Stage IIIB standards.	The demand for standards is increased progressively, seeking to achieve decarbonization of yellow machinery.		• Minambiente • Minenergía • Mintransporte • IDEAM • ANLA • Local environmental authorities • Machinery suppliers • Raw material extraction companies
Embodied carbon	Emissions are progressively reduced by incorporating energy-efficient strategies in raw material extraction and processing.			• MinCIT • Minambiente • Minenergía • Local environmental authorities • Raw material extraction companies • Banking • Academia
Embodied carbon	The extraction of virgin raw materials is progressively reduced from the optimization of the material design (optimized sections, reduction in the use of materials, etc.).			• Minambiente • Minvivienda • MinCIT • Guilds associated with the main manufacturers • Companies manufacturing materials • ICONTEC • Academia
Embodied carbon	Environmental Product Declarations (EPD) are widely used.	One hundred percent of materials and products related to the construction sector have EPD.	N.A.	• MinCIT • Minambiente • Minvivienda • Guilds associated with the main manufacturers • Companies manufacturing materials • ICONTEC • Academia

Energy and Water Use

In the subcategory of **energy and water use** in the manufacturing process, nine goals were generated focusing on improving energy efficiency; decarbonizing production processes; reducing water consumption, and promoting circular management of this resource. For this purpose, actions aim at the development of incentives and requirements to improve energy efficiency in the industry and to promote electrification processes, fuel replacement, use of alternative energies, and the development and implementation of technologies such as carbon capture and storage and use of hydrogen.

Table 9. Goals. Use of energy and water in the manufacturing process.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	A 15% reduction in energy consumption and/or emissions in industrial production has been achieved in the corresponding energy demand module.	Energy consumption and/or emissions in industrial production are progressively reduced in the corresponding energy demand module.		• Minenergía • MinCIT • Minambiente • UPME • Guilds associated with the main manufacturers • Companies manufacturing materials • Chambers of Commerce • Academia
Embodied carbon	Energy efficiency in brick production has increased, with an annual compound growth of 1.5%.	Energy consumption and/or emissions in brick production are progressively reduced in the corresponding energy demand module.		• MinCIT • Minambiente • Minenergía • UPME • Andi's brick manufacturer's committee • Brick manufacturers • Chambers of Commerce • Academia
Embodied carbon	Substitution of 25% of fossil energy demand in cement production plants has been achieved through co-processing (with residues, materials, and by-products).	Substitution of 60% of fossil energy demand in cement production plants has been achieved through co-processing (with residues, materials, and by-products).	Eighty percent of fossil energy demand in cement production plants has been replaced by co-processing (with waste, materials, and by-products).	• MinCIT • Procemco • Minambiente • Minenergía • UPME • DNP • Minciencias • Procemco • Cement industry • Academia
Embodied carbon	The use of non-conventional sources of renewable energy in the production processes for construction materials increases progressively.			• Minenergía • Minambiente • UPME • CREG • Companies manufacturing materials • Companies providing energy services • Academia
Embodied carbon	Electrification of the manufacturing processes for building materials increases progressively.			• Minenergía • MinCIT • Minambiente • UPME • Guilds associated with the main manufacturers • Companies manufacturing materials • Chambers of Commerce • Academia
Embodied carbon	The intensity of carbon associated with brick production in Colombia improves progressively (carbon footprint reduction target of 15% compared to 2020).	The intensity of carbon associated with brick production improves progressively (carbon footprint reduction target of 30% compared to 2020).	The intensity of carbon associated with brick production improves progressively (carbon footprint reduction target of 50% compared to 2020).	• MinCIT • Minambiente • Andi's brick manufacturer's committee • Brick manufacturers • Chambers of Commerce • Academia
Embodied carbon	The intensity of carbon associated with steel production improves progressively (carbon footprint reduction target of 15% compared to 2020).	The carbon intensity associated with steel production is progressively improved (target of carbon footprint reduction 30% compared to the year 2020).	The carbon intensity associated with steel production is progressively improved (target of carbon footprint reduction 50% compared to the year 2020).	• MinCIT • Minambiente • Minenergía • UPME • Andi's steel manufacturer's committee • Steel producing and transforming companies • Academia
Resilience	Water consumption in the manufacturing processes of construction materials is progressively reduced.			• Minambiente • Minvivienda • Environmental authorities • Water and sewerage utility companies • Companies manufacturing materials • Guilds associated with the main manufacturers • Academia

Transport and Distribution

In the third subcategory, **Transport and Distribution**, two goals are proposed focusing on improving logistics operations and adopting low- and/or zero-emission vehicles, for which minimum vehicle requirements must be generated, in addition to establishing strategies and incentives to facilitate the introduction of clean cargo vehicles.

Table 10. Goals. Transport and distribution.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	Emissions associated with transportation and handling of materials are progressively reduced by improving logistics operations and associated processes.			• Mintransporte • Minambiente • Minvivienda • Local environment and mobility authorities • Cargo transport guild • Material manufacturers • Transport companies
Embodied carbon	Seventy percent of the diesel-cycle land mobile sources that provide transport services for construction materials in the country comply with the maximum permissible emission limits of pollutants, which corresponds to the Euro VI emission standard.	One hundred percent of the diesel-cycle land mobile sources that provide transport service for construction materials in the country comply with the maximum permissible emission limits of pollutants, which corresponds to the Euro VI emission standard. Pilot projects have been developed for the application of new technologies available (e.g., trucks that use hydrogen and electricity).	New zero-emission and very low-emission technologies have been adopted for the transport of construction materials.	• Mintransporte • Minenergía • Minambiente • Minhacienda • Local mobility, environment, and health authorities. • Cargo transport guild • Material manufacturers • Transport companies • Commercial banking

New Buildings

Achieving the goals of the category on materials requires training and collaboration among the industry, as well as much research and development. With this in mind, the creation of a knowledge HUB regarding materials and the development of the necessary skills for optimization and innovation in materials is proposed. Similarly, the need to develop different financial mechanisms to promote research and development, energy efficiency, decarbonization of processes, technological reconversion, and the development of incentives to stimulate the use of sustainable products and materials is also identified.

In turn, the goals of the category for **New Buildings** were divided into nine (9) subcategories: (i) selection and use of materials; (ii) design and construction practices and processes; (iii) licenses and sustainable building codes; (iv) structural systems; (v) electrification of end-uses; (vi) labeling; (vii) certification systems; (viii) use of energy and water in the construction process; and (ix) waste generation in the construction process.

Material Selection and Use

The first subcategory, **Material Selection and Use** establishes three goals and various actions that focus on the measurement and reduction of embodied carbon in buildings by using tools such as LCA to select low-carbon materials and optimize building designs. In addition, they focus on promoting the use of materials that prove to be low in carbon, stimulating the creation of markets for these products and thus the mobilization of the materials industry.

Table 11. Goals. Selection and use of materials.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	Most buildings have included embodied carbon as a design factor. The use of materials has been reduced by optimizing the design of the buildings.	Embodied carbon is included as a design factor in all new buildings. The embodied carbon emission factor is reduced by 20% by optimizing the design of the buildings. The reduction is for new buildings compared to 2020.		• Minvivienda • Construction companies, developers, and designers • Camacol and CCCS
Embodied carbon	One hundred percent of the new public projects and large remodeling projects use LCA in at least the structure and envelope.	One hundred percent of new construction projects and major renovations use LCA on a mandatory basis.	N/A	• Minvivienda • Minambiente • Construction companies, developers, and designers • Camacol and CCCS
Embodied carbon	Twenty percent of project materials and components by volume are low in embodied carbon.	Fifty percent of project materials and components by volume are low in embodied carbon.	Sixty percent of project materials and components by volume are low in embodied carbon.	• Minvivienda • Minambiente • MinCIT • Construction companies, developers, and designers • Manufacturers of materials

Design and Construction Practices and Processe

The second subcategory, **Design and Construction Practices and Processes**, proposes three goals aimed at having best practices and processes for design and construction for which the development of energy efficiency codes for buildings is considered, together with strategies that stimulate and generalize the use of bioclimatic designs, sustainability tools, and collaborative methodologies.

Table 12. Goals. Design and construction practices and processes.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	There is a widespread use of bioclimatic designs in projects.	One hundred percent of the projects carry out bioclimatic designs.	N/A	• Minvivienda • Mineducación • Builders, consultants, and designers
Embodied carbon Operational carbon	The use of collaborative methodologies in the design and construction processes of projects has increased.	Collaborative methodologies are widely used in project design and construction processes.	One hundred percent of the projects use collaborative methodologies in the design and construction processes.	• Minvivienda • CAMACOL • Curators and urban planning departments • Builders, consultants, and designers
Operational carbon	The use of sustainability tools (energy modeling, thermal modeling, daylight, water balance, etc.) has increased in the projects.	There is a widespread use of sustainability tools (energy modeling, thermal modeling, daylight, water balance, etc.) in projects.	One hundred percent of the projects use sustainability tools (energy modeling, thermal modeling, daylight, water balance, etc.).	• Minvivienda • Mineducación • Builders, consultants, and designers

Licenses and Sustainable Building Codes

The third subcategory of **licenses and sustainable building codes** sets two goals that aim to include resiliency measures in building codes and to strengthen sustainable building requirements, until reaching a net zero-carbon building code in its entire life cycle. To do this, it is proposed to include resilience measures in the sustainable building code, develop an energy efficiency code, and, with the regular update of Resolution 549, evolve toward buildings with net zero-carbon emissions. A monitoring mechanism supported by a digital tool must be developed and incentives generated to accelerate processes with pioneering projects.

Table 13. Goals. Licenses and sustainable building codes.

Effect in:	2030	2040	2050	Stakeholders involved
Resilience	Fifty percent of the POTs incorporate studies of vulnerability and risk to climate change/extreme weather events, which allow for adaptation and risk management measures to be developed in the projects.	Seventy percent of the POTs incorporate studies of vulnerability and risk to climate change/extreme weather events, which allow for adaptation and risk management measures to be developed in the projects.	One hundred percent of the POTs incorporate studies of vulnerability and risk to climate change/extreme weather events, which allow for adaptation and risk management measures to be developed in the projects.	• Minvivienda • Curators and urban planning departments • Builders, consultants, and designers
Embodied carbon Operational carbon	All new buildings and large renovations comply with Resolution 549 or sustainable building code (includes VIS, VIP, warehouses, and public buildings), assuming energy saving increases of approximately 5% every 5 years.	All new buildings and major renovations meet the operational zero carbon sustainable building code and meet Embodied carbon requirements (including VIS, VIP, warehouses, and public buildings), which are part of the progressive increases of Resolution 549.	N/A	• Minvivienda • Curators and urban planning departments • Builders, consultants, and designers

Structural Systems

The fourth subcategory, **Structural Systems**, establishes two goals focused on increasing the uses of low-carbon structural systems for which research and development and the generation of technical standards, and the inclusion of new systems in the seismic-resistant standard should be promoted.

Table 14. Goals. Structural systems.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	The use of low-carbon structural systems is progressively increased.			• Minvivienda • Minambiente
Embodied carbon	One point five percent of new buildings built have structural systems in timber.	Three-point five percent of new buildings built have structural systems in timber.	Six-point seven percent of new buildings built have structural systems in timber.	• MinCIT • ICONTEC • CAPRCSR and AIS • Manufacturers of materials • Designers and builders

Electrification of End-Use Energy

The fifth sub-category, **electrification of end-use energy**, establishes three goals focused on buildings avoiding the use of fossil fuels and using efficient and clean systems, for which it proposes actions aimed at promoting the decarbonization of cooking systems and facilitating the acquisition of eco-technologies.

Table 15. Goals. Electrification of final energy uses.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	One hundred percent of new buildings and large residential renovations of strata 5 and 6 as well as commercial and institutional in urban areas have all their final energy uses electrified.	All new buildings and major renovations in urban areas have all their final energy uses electrified.	N/A	• Minenergía • Minvivienda • UPME • Minambiente • Energy operators • Constructors • Commercial banking • Civil society
Operational carbon	The national BAT (Best Available Technology) has been adopted in all equipment and systems of new buildings and large renovations in urban areas.	The international BAT has been adopted in all equipment and systems of new buildings and large renovations in urban areas.	The best technology currently available has been adopted in all equipment and systems of new buildings and large renovations in urban areas.	• Minenergía • Minvivienda • MinCIT • UPME • ANDI • Commercial banking • Civil society
Operational carbon	Fifteen percent of new residential buildings have installed solar panels (starting with 10% in 2026).	Thirty-five percent of new residential buildings have installed solar panels.	Fifty percent of new buildings have installed solar panels.	• Minenergía • Minvivienda • Minhacienda • UPME • CREG • Public utility companies

Labeling System

The sixth subcategory establishes a goal for the development and implementation of a **labeling system** for new buildings that integrate operational and embodied carbon footprint. For this purpose, a baseline and indicators must be defined by building typology, and the verification mechanisms of the system and its scalability must be established from a voluntary to a mandatory scheme. Additionally, it must be ensured that it is articulated with Resolution 549 or another sustainable building code generated.

Table 16. Goals. Labeling.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon Embodied carbon	The new buildings label has been effectively implemented voluntarily.	The new building label is mandatory, integrating embodied carbon footprint.		• Minenergía • Minvivienda • Construction companies

Certification Systems

The seventh subcategory, **Certification Systems**, also proposes a single goal for all certification systems used in Colombia to have a net zero-carbon scheme that includes both operational and embodied carbon. It is important to promote certification systems that have a concept of net zero carbon in their whole life cycle to reward pioneering projects. To this end, it is important to develop incentives and benefits, understanding the equivalences among the certification systems available in the market and to differentiate the benefits according to the project's actual impact or contribution.

Table 17. Goals. Certification systems.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon Embodied carbon	All certification systems have developed a net zero-carbon scheme that includes operational and embodied carbon for new buildings.	N/A	N/A	• Minvivienda • Minagricultura • CCCS • CAMACOL • Minhacienda • Local governments • Associations working with rural communities • Design and construction companies.

Use of Water and Energy in the Construction Process

The eighth sub-category, **Use of Water and Energy in the Construction Process**, proposes two goals that focus on decarbonization of the construction process using low- or zero-emission machinery and NCRE in construction works. In addition, three goals are proposed focused on promoting a circular and sustainable management of water in constructive processes through incentives and the strengthening of the regulation.

Table 18. Goals. Use of energy and water in the construction process.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	The use of yellow machinery has been regulated in the country, so the machinery used in building construction has minimum Tier 4 Interim or Stage IIIB standards.	The demand for standards has increased progressively, seeking to achieve decarbonization of yellow machinery.		• Minambiente • Mintransporte • IDEAM • ANLA • Local environmental authorities • Machinery suppliers • Construction companies
Embodied carbon	The incorporation of NCRE as the main energy supply in the works has increased progressively.		One hundred percent of the energy used in the construction site is supplied by NCRE.	• Minambiente • Minvivienda • Energy utility companies • Local environmental authorities • Construction companies
Resilience	Water consumption in work processes is progressively reduced.			• Minambiente • Minvivienda • Local environmental authorities • Water and sewerage utility companies • Construction companies
Resilience	The use of alternative water sources in construction processes (rain, gray, and post-industrial waters) has increased progressively.			
Resilience	The quality of discharges from the works has improved progressively and their volume has reduced.			

Waste Generation in the Construction Process

Finally, the last subcategory, **Waste Generation in the Construction Process**, establishes a goal to progressively increase the percentage of utilization of CDW, for which it proposes actions aimed at improving the practices of separation in site and circularity and promoting business models that motivate these activities.

Table 19. Goals. Waste management in the construction process.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	A percentage by weight of the total construction and demolition waste (CDW) generated on site has been effectively diverted from landfill disposal, according to the category of the municipality where it is located: Special category 75%; categories 1-2-3, 60%; and categories 4-5-6, 40%.	The percentage of CDW diverted from landfill disposal has increased progressively.		• Minambiente • Minvivienda • Environmental authorities • Construction companies • CDW management Companies • SENA

Existing Buildings

The category for **existing buildings** is divided into eight emission subcategories, which are: (i) use of energy and water during operation; (ii) emission of refrigerant gases by cooling or air conditioning systems; (iii) generation and management of domestic solid waste; (iv) process of remodeling and adaptation; (v) use of energy in the deconstructive process; (vi) Demolition waste management, recycling, and reuse; (vii) release of refrigerant gases in the final disposal of cooling or air conditioning equipment; and (viii) transport of demolition waste.

Use of Water and Energy During Project Operation

The first, **Use of water and energy during project operation**, sets six goals focused on achieving an efficient and de-carbonized operation. Among the strategies identified to reduce the use of water and energy during the operation of buildings are: the inclusion of sustainability requirements from the energy efficiency codes and energy labeling; the use of tools for the adaptation of buildings, such as energy audits and retrofit processes; the electrification of systems; and optimization of water resources with a focus on circularity.

Table 20. Goals. Water and energy use during project operation.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	A sustainable building code with energy efficiency requirements is implemented on a mandatory basis for existing public and commercial buildings, and voluntarily for residential buildings.	A sustainable building code with energy efficiency requirements for residential buildings has been implemented and the code for public and commercial buildings has been strengthened to comply with a zero code.	All existing buildings implement an operational zero-carbon construction code.	• Minenergía • Minvivienda • UPME Minhacienda • Public utility companies
Operational carbon	Existing dwellings in strata 5 and 6 have electrified 80% of their final uses. Existing dwellings in strata 1, 2, 3, and 4 have electrified 70% of their final uses. Existing commercial and public buildings have electrified 80% of their end uses.With this, a 50% share of electricity at the sectoral level is achieved.	Existing dwellings in strata 5 and 6 have electrified 100% of their final uses. Existing dwellings in strata 1, 2, 3, and 4 have electrified 85% of their final uses. Existing commercial and public buildings have electrified 100% of their final uses.With this, a 72% share of electricity at the sector level is achieved.	Existing dwellings in strata 1, 2, 3, and 4 have electrified 94% of their final uses. At the sectoral level, a 94% share of electricity would be achieved in 2050. The remaining 6% is GLP participation in rural areas.	• Minenergía • Minvivienda • UPME • Minambiente • Energy operators • Constructors • Commercial banking • Civil society
Operational carbon	An energy label for existing buildings has been developed.	A voluntary energy label for existing buildings has been effectively implemented.	The energy label for existing buildings has been implemented as a mandatory requirement.	• Minenergía • Minvivienda • Associations of real estate agents and operators
Operational carbon	The national BAT has been gradually adopted in the appliances and systems of existing buildings.		The international BAT has been adopted in the appliances and systems of existing buildings in urban areas.	• Minvivienda • Minenergía • MinCIT • UPME • ANDI • Commercial banking • Civil society
Resilience	Water consumption in the operation has been progressively reduced.			• Minambiente • Minvivienda • Environmental authorities • Water and sewerage utility companies • Operators
Resilience	The use of alternative water sources in the operation (rain waters, gray waters, and post-industrial waters) has progressively increased.			

Emissions of Refrigerant Gases by Cooling or Air Conditioning Systems

The next sub-category, **emissions of refrigerant gases by cooling or air conditioning systems**, has a target focused on the progressive reduction of GHG emissions using HFC substitutes. For this, the labeling of household appliances and the operation and maintenance processes should be strengthened, as well as facilitating the financing of HFC-free technologies.

Table 21. Goals. Emission of refrigerant gases by cooling or air conditioning systems.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	An 11% reduction in GHG emissions from the use of HFC substitutes has been achieved.	GHG emissions from the use of HFC substitutes are progressively reduced.		• Minambiente • ACAIRE • CIDARE Research Centre

Generation, and Management of Domestic Solid Waste

The third sub-category, **generation, and management of domestic solid waste**, establishes a goal to increase separation, recycling, and composting practices in buildings with the purpose of reducing the amount of waste that goes to landfill disposal. This requires developing technologies for solid waste management in situ, as well as developing mass awareness campaigns for end users on the importance of waste management, among other things.

Table 22. Goals. Generation and management of domestic solid waste.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	Separation, recycling, and composting practices in buildings have been increased to reduce the amount of waste going to landfill disposal from the buildings.	Separation, recycling, and composting practices in buildings have been increased to reduce the amount of waste that goes to landfill disposal from the buildings, achieving that less than 45% of the waste reaches final disposal.	Separation, recycling, and composting practices in buildings have been increased to reduce the amount of waste that is going to landfill disposal from the buildings, achieving that only 35% of the waste reaches final disposal.	• Minvivienda • Minambiente • Local governments • Civil society

Remodeling, and Adaptation Processes

As for the fourth subcategory, **remodeling, and adaptation processes**, three goals are established focused on generating minimum performance requirements for buildings undergoing remodeling processes. This involves the inclusion of mandatory and voluntary verification and control mechanisms to improve the performance of existing buildings, developing energy efficiency codes for remodeling, including requirements for periodic energy audits, and training real estate managers and operators.

Table 23. Goals. Process of remodeling and adaptations.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	Licenses associated with remodeling include compliance with the updated Resolution 0549 or other regulations developed for zero net buildings.	Licenses associated with remodeling include a requirement for compliance with the regulations for net zero buildings.	N/A	• Minambiente • Minvivienda • Minhacienda • Local governments
Operational carbon	All certification systems have developed a net zero-carbon scheme that includes operational carbon for existing buildings.	N/A	N/A	• Minambiente • Minenergía • Minvivienda • Minhacienda • Local governments • Construction
Operational carbon	The use of energy audits leading to a retrofit process has increased.	There is a widespread use of energy audits leading to a retrofit process.	One hundred percent of existing buildings carry out energy audits leading to a retrofit process.	• Minenergía • Minvivienda

Energy Use in the Deconstruction Process

The fifth subcategory, **energy use in the deconstruction process**, has a goal aimed at the use of clean yellow machinery, which involves developing regulatory guidelines for the inclusion of yellow machinery with low emission levels, generating incentives for the acquisition of new machinery, creating restrictions on the entry of polluting machinery into the country, and developing a plan for the scrapping of old machinery, among other actions.

Table 24. Goals. Use of energy in the construction process.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	The use of yellow machinery has been regulated in the country, so the machinery used for the demolition of buildings has minimum Tier 4 Interim or Stage IIIB standards.	The demand for standards has increased progressively, seeking to achieve decarbonization of yellow machinery.		• Minambiente • Minenergía • Mintransporte • IDEAM • ANLA • Local environmental authorities • Machinery suppliers • Construction companies

Demolition Waste Management, Recycling, and Reuse

The sixth subcategory, **demolition waste management, recycling, and reuse**, sets two goals to improve demolition processes and increase the amount of demolition waste going to circularity processes, which involves the development of building passports and the implementation of decommissioning processes.

Table 25. Goals. Exploitation, recycling, and reuse.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	The use of pre-demolition audits (decommissioning) leading to better demolition processes has increased.	There is a widespread use of pre-demolition (decommissioning) audits that lead to better demolition processes.	One hundred percent of existing buildings to be demolished carry out pre-demolition audits (decommissioning) leading to better demolition processes.	• MinCIT • Minvivienda • Minambiente • Local governments • Private sector
Embodied carbon	It has been achieved that 50% of the demolition waste is sent to circularity processes.	It has been achieved that 75% of the demolition waste is sent to circularity processes.	It has been achieved that 90% of the demolition waste is sent to circularity processes.	• MinCIT • Minvivienda • Minambiente • Local governments • Private sector

Emissions of Refrigerant Gases in the Final Disposal of Cooling or Air Conditioning Equipment

The seventh sub-category, **emissions of refrigerant gases in the final disposal of cooling or air conditioning equipment**, has a goal focused on environmentally sound management of end-of-life ozone-depleting substances (HFCs). To this end, continuity must be given to the plans coordinated by the Ozone Technical Unit under the guidelines defined in the Montreal Protocol, its amendments, and the latest Kigali Protocol, which was ratified by Colombia in 2020.

Table 26.Goals. Emission of refrigerant gases in the final disposition of the cooling or air conditioning equipment.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon	Environmentally sound management of end-of-life ozone-depleting substance (HFCs) substitute product banks has progressively increased.			• Minambiente • UTO • Acaire • CIDARE • ANDI - appliances table

Transport of Demolition Waste

Finally, for the **transport of demolition waste**, a goal has been set for efficient and low-carbon transport. This requires developing public policy requirements for efficient, low-carbon transport, and implementing strategies to introduce low-emission or clean vehicles.

Table 27. Goals. Transport of demolition waste.

Effect in:	2030	2040	2050	Stakeholders involved
Embodied carbon	Seventy percent of the diesel-cycle land mobile sources that provide transport services for construction materials in the country comply with the maximum permissible emission limits of pollutants, which corresponds to the Euro VI emission standard.	One hundred percent of the diesel-cycle land mobile sources that provide transport service for construction materials in the country comply with the maximum permissible emission limits of pollutants, which corresponds to the Euro VI emission standard. Pilot projects have been developed for the application of new technologies available (e.g., trucks that use hydrogen and electricity).	New zero-emission and very low-emission technologies have been adopted for the transport of construction materials.	• Mintransporte • Minenergía • Minambiente • Minhacienda • Local mobility, environment, and health authorities. • Cargo transport guild • Manufacturers of materials • Transport companies • Commercial banking

It is important to emphasize that the achievement of all new and existing building goals requires training for all stakeholders along the construction value chain from formal and non-formal education. It is necessary to develop the skills of professional staff members so that they can comply with the standards of sustainable construction, and integrate strategies of energy efficiency, resilience, and water management, among others. In addition, the training of public officials is necessary so that they can formulate and follow up on the policies and regulations developed. It is also necessary to raise public awareness on the importance of decarbonization of buildings as well as of using resources efficiently and circularly. Finally, the allocation of resources is necessary for the development and implementation of monitoring, reporting, and verification mechanisms as well as to foster research and development processes. There is also a need for the development of different financing mechanisms and incentives to facilitate the adoption of technologies and accelerate market changes.

Informal Settlements

Finally, in the category of **informal settlements**, a goal is proposed to reduce the proportion of informal housing by improving access to low-cost housing. To this effect, strategies are proposed such as facilitating licensing processes, providing accompaniment and financial education to make access to formal housing viable, and developing alternative schemes for access to formal housing aimed at people without access to financing. Additionally, for existing informal settlements, it is proposed that the current neighborhood and housing improvement programs integrate both livability strategies and sustainability and efficient use of resources.

Table 28. Goals. Informal settlements.

Effect in:	2030	2040	2050	Stakeholders involved
Operational carbon Embodied carbon Resilience	The share of informal housing has been reduced to 16% (national average) through improved access to low-cost housing.	The share of informal housing has been reduced to 11% (national average) through improved access to low-cost housing.	The share of informal housing has been reduced to 5% (national average) through improved access to low-cost housing.	• Minvivienda • Minambiente • DNP • Minhacienda • Local governments • Civil society • Camacol • Academia • Financial institutions

Sub-national actions

Each of the categories and sub-categories of the national roadmap presents local actions required to develop an action plan that contributes to and is aligned with national goals. To achieve these goals nationwide, it is essential that every local government uses this as a basis for the development of local action plans tailored to the contexts of each location.

The actions are mainly focused on adapting national regulations to the specific climatic and social conditions of each municipality, as well as on the development of local incentives to accelerate the processes.

FROM THE ROADMAP TO A LIVING DOCUMENT

While this roadmap provides a fundamental starting point, it is necessary to review the proposed targets and the mitigation scenario once the country develops more mechanisms to have more available information and once there are technological advancements. This will allow closing the gaps that still exist regarding the decarbonization goals (especially in terms of embodied carbon) and to be even more ambitious.

Having better information from the building sector in Colombia will allow for a more disaggregated and complete baseline that will also be relevant to follow up on progress regarding the goals proposed in the roadmap. The lack of detailed information for baseline characterization did not allow for the analysis of mitigation options for some emission sources. Therefore, in the future, it will be necessary to explore their mitigation potential[5].

This roadmap is intended as the starting point so that different sectors can set specific targets and develop policy instruments. This requires that the roadmap be a living instrument, adapted periodically and evolving as the country moves towards decarbonization.

[5] To see the details of the mitigation options that could not be analyzed, please refer to: Assessment of GHG Emissions Mitigation Measures from Buildings in Colombia. Prepared by Universidad de los Andes and Hill consulting, 2022.

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