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Electricity transmission in Colombia: overview 2025

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Electrical substation and high-voltage towers, Colombia © HumbertoJose92 / Getty

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Key messages

- **The transmission infrastructure faces a structural backlog in the context of expanding electricity generation, predominantly from renewable sources. With a total installed capacity of 20.9 gigawatts (GW) and an additional 18 GW already approved, total installed generation capacity is projected to reach 38.9 GW by 2030.**
- **The National Interconnected System (SIN) is approaching its operational limits: less than 5% of transmission capacity is available, and within the next five years, 90% of substations will exhaust their short-circuit interrupting capacity, which will compromise the integration of new generation projects.**
- **The sector's main challenge is implementation: 55% of the 20 transmission projects currently underway are delayed, with some by around a decade, such as Bacatá-Norte (12 years), and Sogamoso Norte-Nueva Esperanza (10 years).**
- **These delays are due to socio-environmental factors, difficulties in licensing and permits, and a weak alignment between national energy planning and land-use planning instruments.**
- **The Master Plan for Modernization and Expansion of the Electrical Transmission Infrastructure sets out an indicative portfolio of 98 strategic works. By developing just 44 of them, it would be possible to overcome 149 operational constraints projected between 2024 and 2037.**
- **In 2025, the Mining and Energy Planning Unit (UPME) formally adopted the Territorial Engagement Model, marking an institutional shift towards the integration of socio-environmental and cultural criteria into the planning of the electricity sector.**

This document provides an overview of the electrical transmission[1] sector in Colombia as of 2025. It begins by presenting the institutional and regulatory framework, along with a general description of the National Interconnected System (SIN) and the agents involved. In the following sections, we provide an overview of the SIN access process and the main challenges facing the sector. The document concludes with a commentary on perspectives for the future.

1 Refers to the high-voltage infrastructure (> 57.5 kV) that connects generation plants to distribution networks and to the large users of the system. This document does not address the Local Distribution System (SDL) (voltages < 57.5 kV).

1. Institutional and regulatory framework

The Colombian electricity sector, including the transmission segment, is structured under laws 142 and 143 from 1994, which liberalized the market and established the separation of generation, transmission, distribution and commercialization activities. (Congreso de la República de Colombia, 1994a, b). Under this framework, transmission is conceived as a regulated natural monopoly[2] with open access and declared a public service of a general interest. These laws also establish the framework for state intervention in essential aspects of the system's operation, such as the definition of tariffs and remuneration methodologies, the regulation of network access, service quality and continuity, and the operating rules of the SIN.

Additionally, Laws 142 and 143 establish the institutional framework of the SIN, highlighting the Ministry of Mines and Energy (MME), the Energy and Gas Regulatory Commission (CREG), the Mining and Energy Planning Unit (UPME), the National Dispatch Center (CND operated by XM), and the Superintendency of Residential Public Services (SSPD). Other key institutions from an environmental perspective are the National Environmental Licensing Authority (ANLA) and the Regional Autonomous Corporations (CARs).

With regards to the operation of the SIN, where transmission plays a key role, the CND is responsible for dispatching and operational coordination. Meanwhile, the ownership, construction, and operation of transmission assets correspond to the sector's agents – the National Transmitters (TN) and Grid Operators (OR) – and are governed by CREG regulations and other sector-specific provisions.

UPME is the entity responsible for developing the Generation and Transmission Expansion Plans (UPME, n.d.-e), in accordance with the Planning Code guidelines established in CREG Resolution 025 of 1995, CREG Resolution 022 of 2001 and MME Resolution 181313 of 2002. The Transmission Expansion Plans are fundamental instruments for the planning of the SIN and are mandatory. The plans involve an analysis of the electricity transmission networks based on electricity demand projections, and they identify the expansion needs and priorities of the current SIN in the short, medium, and long term.

2 Implies that all services can be provided by a single "company" at a lower cost than what would be achieved by several companies competing in this field.

2. The National Interconnected System (SIN) and its agents

The SIN is subdivided into the National Transmission System (STN), the Regional Transmission System (STR), and power plants and generation equipment, depending on the operating voltage level defined by CREG Resolution 015 of 2018. Due to its geographical characteristics, grid topology, and the location of its generation facilities, the SIN is organized into five operating areas: Antioquia, Caribbean, Northeastern, Eastern and Southwestern. Each of these is further broken down into various sub-areas for operational management.

The total length of the SIN as of 2025 is 30 205 km, distributed throughout the STN and the STR (XM, n.d.). The STN comprises the powerlines, substations, and associated equipment that operate at voltages of 220 kilovolts (kV) or higher and consists of 133 substations, of which 23 operate at 500 kV. For its part, the STR takes electricity from the STN and distributes it at the regional level. The STR comprises the assets connecting the STN and the network of lines and substations that operate at Voltage Level 4.[3] In total, 367 substations make up the STR, all operating at voltages lower than 138 kV and higher than 57.5 kV, according to the SIN Technical Parameters Portal (PARATEC). Table 1 summarizes the composition of the STN and STR and the extent of their transmission lines as of November 2025.

Table 1. Composition of the STN and STR as of 2025

System	Voltage level (kV)	Substations (quantity)	Lines (km)
STN	500	23	4507.26
	220–230	110	13 690.71
STR	110–115	351	11 807.46
	57.5–66	16	265.17

This structure provides the framework for organising the agents responsible for developing the transmission projects. For the STN, the highest-voltage system, the main operator is the National Transmitter (TN) – defined as the legal entity that constructs, operates and maintains the STN transmission project. The STN projects set out in the Transmission Expansion Plans are approved annually by the MME and are made mandatory by ministerial decree. They are awarded through open tenders known as Transmission Bids (UPME, n.d.-h) which, although under the responsibility of the MME, have been delegated to the UPME through Resolution 180924 of 2003 and Decree 1258 of 2013 (UPME, n.d.-h; Presidencia de la República, 2013; Ministerio de Minas y Energía, 2003).

3 Voltage Level 4: Nominal voltage greater than or equal to 57.5 kV and less than 220 kV, according to CREG Resolution 015 of 2018.

Since the tender mechanism was established, 72 projects have been carried out for the STN. These include the construction of new substations, transmission lines, transformer replacements, increased transmission capacity, installation of capacitive compensations, and, more recently, synchronous compensation (Box 1) (UPME, 2024a). These projects are not a concession: The assets belong to the investor. According to CREG Resolution 022 of 2001, the State does not establish any contractual relationship with any investor. The successful bidder must execute the project at its own expense and risk, without acting on behalf of the State. Through the Annual Expected Revenue (IAE) received over 25 years, the successful bidder covers its investment, operation, and maintenance costs. From year 26 onward, IAE calculation is adjusted based on the replacement cost of the assets, and the methodology set out in CREG Resolution 022 of 2001 is applied.

BOX 1. SYNCHRONOUS COMPENSATORS

Synchronous compensators are electromechanical devices that, without generating energy, provide inertia, reactive power control, voltage stability, short-circuit current, and grid strength. This is critical in areas with low grid robustness or high penetration of variable renewable generation, where their presence helps maintain frequency, mitigate fluctuations and prevent blackouts (UPME, 2024a).

UPME has proposed the installation of 15 synchronous compensators, mainly in the Caribbean region (UPME, 2024b). Two calls for tenders have been issued for the installation of synchronous compensators: UPME 03-2024 for the Maicao and Santa Marta substations, and UPME 04-2024 for the El Banco, Guatapurí, and La Jagua substations, as part of the national electricity system modernization plan (UPME, 2024b, n.d.-f,g).

The conversion of decommissioned thermal generators into synchronous compensators has also been recognized in sector planning as an alternative to utilize existing infrastructure, reduce costs and facilitate the provision of stability services in the electricity system.

The tender process is conducted under a single-offer reverse auction scheme,[4] with digitally sealed bids and a maximum price cap set by CREG. National and international investors can participate without the need to be incorporated in Colombia as public utility companies (ESP). According to CREG Resolution 022 of 2001, Interconexión Eléctrica S.A. (ISA), a public-private partnership, is required to submit a bid in response to every call for bids regarding the expansion of the STN. Financial bids must correspond to the Annual Expected Revenue (IAE), calculated over 25 years from day one of commercial operations. This must cover all costs and risks throughout the project's life cycle and is discounted to present value using the rate regulated by CREG

4 A mechanism through which UPME awards projects to the bidder that offers the lowest present value of the revenues required to build and operate the defined infrastructure, within a cap regulated by the CREG.

Resolutions 083 of 2008 and 035 of 2010 (UPME, n.d.-h; Presidencia de la República, 2013; Ministerio de Minas y Energía, 2003).

Finally, the State acts as the guarantor as a last resort: If a project included in the Expansion Plan does not receive competitive bids, the State must ensure its development, as established in Article 18 of Law 143 of 1994.

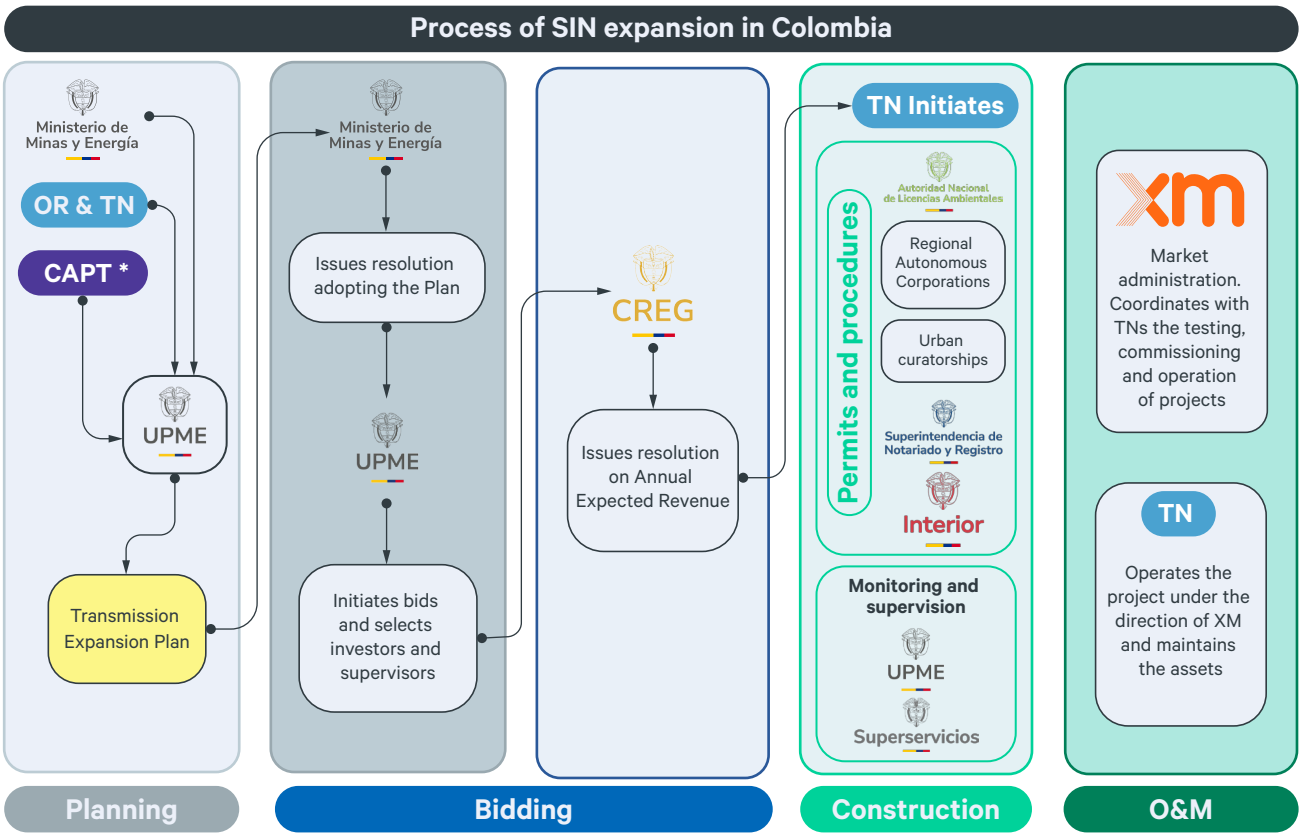
Within the STR – the voltage system with a nominal voltage greater than or equal to 57.5 kV and less than 220 kV – the main agent is the Network Operator (OR). The regulation assigns the OR a more comprehensive role than that of the National Transmitter (TN), with responsibilities for construction, operation, maintenance and planning. The OR has a more proactive role: It must carry out planning, identify expansion needs to meet demand, improve quality or expand coverage, and structure and execute the corresponding projects (CREG, 2013).

CREG Resolution 024 of 2013 sets out the procedures for the expansion of the STR and the efficiency criteria that projects must meet to be approved. The inclusion of a Network Operator (OR) into the STR may occur through one of the following ways: (1) the transfer of assets by commercial agreement between companies (corporate split or corporate merger), in which case the remuneration and recognition rules established in CREG Resolution 015 of 2018 apply; (2) the liquidation of a Network Operator in accordance with the provisions of Law 142 of 1994; or (3) the construction of a project for the STR awarded through an open competitive bidding process in accordance with the provisions of CREG Resolution 024 of 2013.

Investments in the STR, unlike STN assets, are remunerated under the concept of use charges, as defined within the remuneration methodology for electricity distribution within the SIN. These charges are approved by CREG and paid by end users through their electricity bill (CREG, 2018). Use charges are designed to cover the efficient costs of investment, administration, operation and maintenance. These charges, together with the methodology for investment recognition, are established by CREG Resolution 015 of 2018.

CREG Resolution 024 of 2013 also establishes a hierarchical reporting scheme under which ORs must provide the necessary technical information annually to UPME for system planning, including the expansion plan of the system operated by the OR. This input allows UPME to consolidate and harmonize local information when formulating the Transmission Expansion Plan.

Figure 1. Stages of the SIN expansion processes



* Transmission Planning Advisory Committee

BOX 2. THE DUAL MODEL: DIFFERENCES BETWEEN THE STN AND STR

The National Interconnected System (SIN) is divided into two major components based on voltage level:

1. **National Transmission System (STN):** Comprises assets that operate at voltages equal to or greater than 220 kV. Its expansion is governed by a **centralized planning** model; UPME defines the projects in the Expansion Plan and MME adopts them. These projects are awarded through **Public Tenders** (reverse auctions) managed by UPME. The successful investor or National Transmitter (TN) finances, builds, and operates the asset at its own risk and is remunerated through the Annual Expected Revenue (IAE) it bid.
2. **Regional Transmission System (STR):** Comprises assets that operate at voltages between 57.5 kV and 220 kV (Level 4). Its expansion is a **decentralized responsibility** of each **Network Operator (OR)**. The OR must plan, structure and execute its own projects to meet demand and quality standards in its region. However, it must submit its plan annually to UPME, and must obtain technical validation from UPME and approval of the remuneration (via use charges) from CREG.

3. Access to the SIN

Access to the SIN by electricity generators or large users is currently regulated under CREG Resolution 075 of 2021, which establishes the provisions and procedures for the allocation of transmission capacity throughout the entire SIN, regardless of the voltage level. CREG Resolution 075 of 2021 classifies the projects as follows:

Class 1 Projects: projects for connecting end users to the STN or STR, and projects relating to the connection of generation, cogeneration, or self-generation for the SIN, other than those projects falling within the scope of CREG Resolution 030 of 2018, or any resolution that modifies, supplements, or replaces it. Modifications to already assigned capacities will also be considered Class 1 projects.

Class 2 Projects: These apply to end users connecting to the Local Distribution Systems (SDL). This means the electricity network infrastructure, lines, and substations that transport electricity at a voltage of 57.5 kV or lower.

To manage this process, CREG Resolution 075 of 2021 directed the UPME to create a "Single Window", a centralized technological platform where interested parties must submit all connection requests (UPME, n.d.-i). Its operation and operational parameters were defined in UPME Resolution 528 of 2021. Furthermore, to comply with this mandate and to allocate available transmission capacity, the UPME developed the Connection Capacity Allocation Model (MACC), a tool that supports the technical analysis required to evaluate and allocate capacity in the transmission networks (UPME, n.d.-a). The MACC mainly receives applications for Class 1 projects.

The MACC is an optimization model that solves a mixed-integer programming problem, designed to minimize idle system capacity and allocate the maximum possible generation capacity. To this end, it incorporates system-level criteria by operating area and individual criteria for each project. The prioritization of connection requests is based on economic criteria (reduction of constraints, effect on losses, effect on the spot price), technical criteria (emission reduction, increase in reliability, improvement in flexibility), and temporal criteria (environmental licensing procedures), with specific weights assigned to each criterion (UPME, n.d.-d).

The methodology allows the weights assigned to these criteria to be adjusted, which provides flexibility to adapt the weighting to different public policy priorities or technical needs. The proposed values for each indicator are outlined in Table 2 (UPME, n.d.-a,d).

Table 2. Criteria for the allocation of transmission capacity

Criterion	Suggested weight
Reduction of constraints	16.7%
Reduction of losses	16.7%
Effect on spot price	16.7%
Reduction of emissions	16.7%
Increase in reliability	16.6%
Increase in flexibility	16.6%
Total (economic + technical)	100%
Environmental – status of procedures[5]	10%

As a result of the process, UPME issues a connection concept and assigns each applicant a place within the official list published on the Single Window. When the approval is granted, the beneficiary generator, cogenerator or self-generator confirms and accepts the assigned capacity by establishing a financial guarantee for capacity reservation.

In cases where a Class 1 project requires connection to the STN and such connection necessitates grid expansion, UPME may make approval of the capacity allocation conditional upon the interested party agreeing to bear a percentage of the cost of the required grid assets, in compliance with CREG Resolution 075 of 2021. In this scenario, the generator assumes the role of user and is required to establish a financial guarantee to support the construction of the grid expansion project, in accordance with CREG Resolution 022 of 2001 and CREG Resolution 024 of 2013.

Under the transmission capacity allocation procedure set out in CREG Resolution 075 of 2021, UPME carried out two allocation processes/cycles in 2022 and 2023. Although the resolution defines a schedule and deadlines for the publication of the list of generation projects with allocated capacity, the high volume of requests necessitated several adjustments. As a result, the 2023 cycle was delayed and congested, which prevented the opening of the 2024 cycle and led to the suspension of the 2025 cycle for up to 12 months (CREG, 2025a,c).

The high volume of requests, driven in part by the growing interest in developing renewable generation projects, has placed unprecedented pressure on the available capacity within the transmission system. The 2022 allocation cycle received 843 connection requests for a total of 56 gigawatts (GW). Of this total, the UPME assigned approximately 7.5 GW, with renewable sources predominating: 77% (5.7 GW) corresponded to solar projects and 16% (1.2 GW) to wind energy projects, including 350 megawatts (MW) of offshore wind (CREG, 2025c). The 2023–2024 allocation cycle received 1732 requests, more than doubling those submitted in 2022, for a total of 89 GW of requested transmission capacity (UPME, 2025). This increase has congested the process and accelerated the exhaustion of the system's transmission capacity,

5 Discount percentage if the project has not progressed in the permitting process in the processing status; this discount does not apply to projects that have progressed.

reflecting a growing tension between the pace of generation expansion and the structural limitations of the grid (CREG, 2025c).

Forty-one percent of generation projects with assigned capacity depend on the transmission works currently under construction entering into operation.[6] Additionally, to guarantee operational security, meet demand and integrate new generation capacity, Colombia should execute at least 44 of the 98 projects proposed in the Master Plan for the Modernization and Expansion of the Electric Transmission Infrastructure to 2034. Of these, 11 are high-impact projects associated with new substations and their lines (UPME, 2024b).

CREG Resolution 101 094 of 2025 introduces transitional measures to streamline and prioritize the allocation of transmission capacity, which implies significant adjustments to the current process. In particular, it prioritizes projects with firm commitments or with completed environmental procedures, and those that enable network operators (ORs) to allocate capacity to projects under 10 MW in distribution networks, and strengthens coordination between UPME and ORs in areas with multiple requests (CREG, 2025b).

4. Structural challenges of the SIN

4.1 Recurrent delays in project execution

There is a structural difficulty in commissioning and implementing the projects awarded through public tenders within the timeframes laid out in the investor selection documents. As a result, the planning assumptions that guide investment decisions are not met in practice, which leads to suboptimal and economically inefficient solutions.

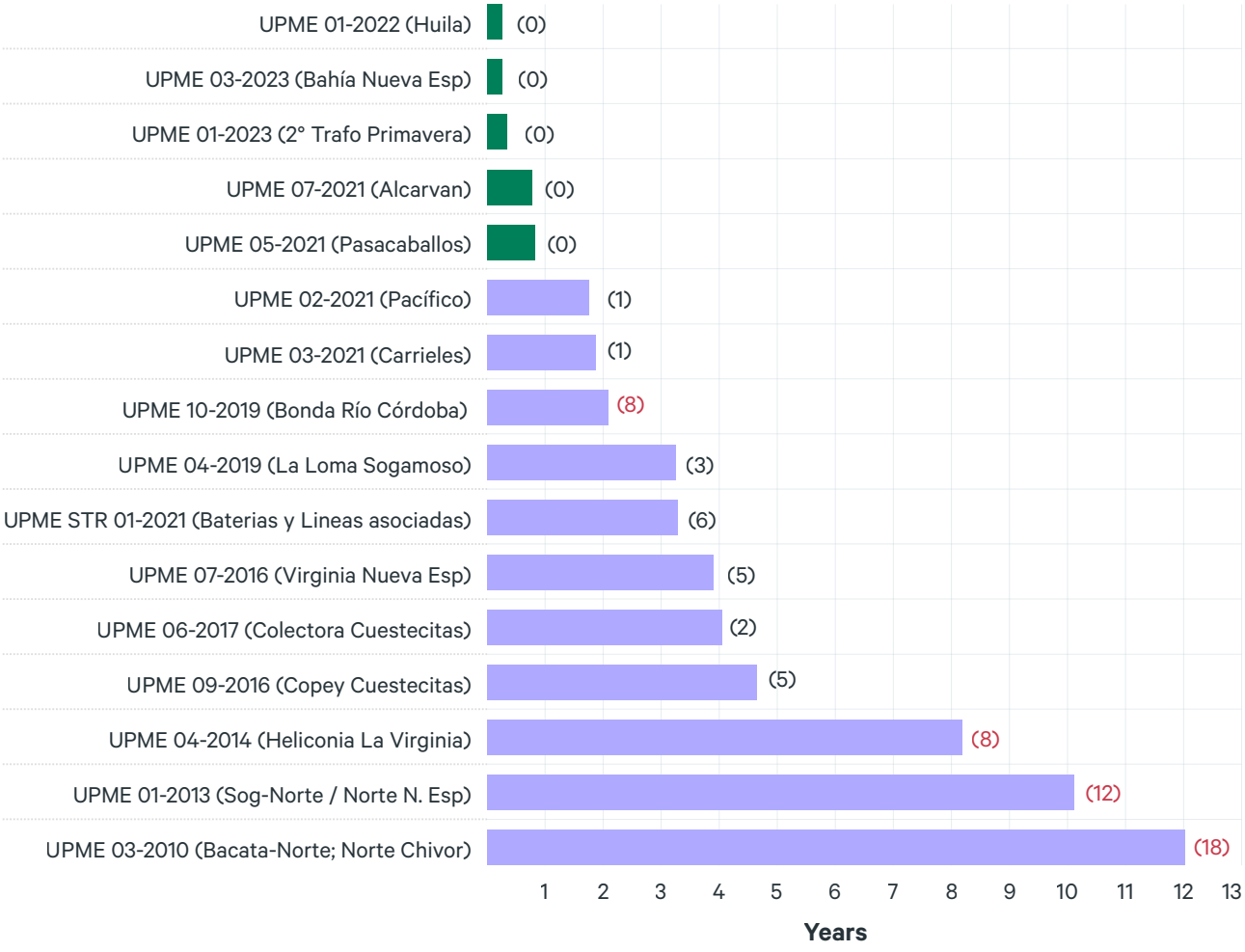
According to the latest quarterly bulletin on the monitoring of UPME bids for the period October to December 2025, with data as of November 2025, Colombia had 21 transmission expansion projects underway. Of these, 55% (11 projects) had delays ranging from one year to 12 years, with some cases involving up to 18 requests for extensions (UPME, 2026). Other projects that have recently begun implementation already show schedule slippage of at least three months, although they have not yet submitted any formal requests for extensions.

Figure 2 shows the accumulated years of delay for transmission projects in the execution phase, as well as the number of extension requests – indicated in parentheses – submitted to modify their estimated Commercial Operation Date (FPO).[7] This trend highlights that project execution dynamics require a significant change to deliver the accelerated and timely deployment of transmission infrastructure demanded by current needs.

6 Value calculated as of November 2025 based on information from the UPME Geovisor, which records the conditions under which the capacity allocation request was approved for the different generation projects.

7 Estimated FPO: Estimated date of commissioning, determined monthly by the project oversight team in accordance with the terms of the request for proposals.

Figure 2. Projects in execution, years of delay according to the estimated FPO, and the number of extension requests



Source: Prepared by the author using data from UPME (2026)

Note: The number in parentheses corresponds to the number of extension requests.

In response to these challenges, UPME has been strengthening its planning function through new investment projects aimed at improving information quality, territorial coordination, and the ability to anticipate socio-environmental and technical risks that affect compliance with FPOs. The Energy Subdirectorate is advancing initiatives to optimize planning instruments and sectoral coordination, while the Territorial Approach Directorate is working to integrate higher-resolution territorial and social information into analyses of the expansion of the SIN (UPME, n.d.-b,c).

4.2 Integration of socio-environmental criteria

Annex 5 of the bidding documents[8] sets out the current socio-environmental regulatory framework applicable to SIN projects, including provisions on environmental licensing, prior consultation, and other sector-relevant obligations.

Decree 1076 of 2015 defines the responsibilities for environmental licensing: ANLA is responsible for STN projects (≥ 220 kV), while Regional Autonomous Corporations (CARs) are responsible for STR projects (between 50 kV and 220 kV). In both cases, Decree 1076 of 2015 requires the preparation of an Environmental Impact Assessment (EIA) in accordance with the terms of reference adopted through Resolution 0075 of 2018. Since August 2025, ruling C-280 of 2024 requires that EIAs incorporate an analysis of climate change impacts (Presidencia de la República, 2015; Ministerio de Ambiente y Desarrollo Sostenible & Autoridad Nacional de Licencias Ambientales, 2018b; Corte Constitucional de Colombia, 2024).

For the development of new STN lines, a request must be submitted to the competent environmental authority for a ruling on the mandatory requirement to present an Environmental Diagnosis of Alternatives (DAA). This tool determines the most environmentally viable route, in accordance with Resolution 2183 of 2016.

In social matters, projects may require prior consultation when the presence of ethnic communities is identified within their area of influence, in accordance with national regulations[9] and OIT Convention 169. Elements such as transmission easements and safety distances are regulated by the Technical Regulation of Electrical Installations (RETIE), which sets out requirements for the installation, operation and safety of infrastructure (Ministerio de Minas y Energía, n.d.).

In 2013, UPME and the MME identified the primary risk factors for the expansion of the SIN: difficulties in environmental licensing; construction and land-use permits; and a disconnection between national energy planning and local Land Use Plans (POT) (UPME, 2013). In 2021, UPME incorporated this assessment into the General Methodology to integrate this territorial approach into the plans formulated by the entity (UPME, 2021a). This methodology acknowledges that the purely economic approach, which was exclusively emphasized until a few years ago, was imprecise and that strategic territorial planning enables the identification, prevention and mitigation of potential socio-environmental conflicts. These principles were adopted by UPME through Resolution 000339 of 2022.

Despite institutional efforts to identify issues and the adoption of the territorial approach, in 2025, the 6GW Strategy confirms the existence of a crisis regarding the commencement of project operations. The strategy sets out operational instruments – referred to as "Dynamizing Strategies" and the "Roadmap"– which aim to transition from diagnosis toward more effective implementation (UPME, 2024e).

8 See, for example, Annex 5 of tenders UPME STR 03 2025, UPME 03-2024 and UPME 05-2023.
9 Integrated into Colombian law through Law 21 of 1991, with procedures established in Presidential Directives No. 08 of 2020, 10 of 2013, and 01 of 2010, and developed in several rulings, such as T-129 of 2011, SU-123 of 2018, T-426 of 2014, and C-369 of 2019.

Additionally, the 6GW Strategy formally incorporates the Territorial Engagement Model as an operational framework for coordination between energy planning, territorial authorities, and communities. The model seeks to institutionalize mechanisms for early dialogue, inter-institutional coordination, the prioritization of routes with minimal socio-environmental impact, and clear measures for the distribution of local benefits (UPME, 2024e).

The 530% increase in the capacity of Non-Conventional Renewable Energy Sources (FNCER) that entered operation in 2024, compared to 2023, suggests that this new approach, although still in consolidation, is beginning to generate positive results (UPME, 2024e).

4.3 Exhaustion of transmission and short-circuit interruption capacity

In addition to the increased administrative burden caused by the high volume of connection requests, UPME faces technical challenges due to the exhaustion of available transmission capacity and the exhaustion of short-circuit interruption capacity at several substations throughout both the STR and STN. Between 2024 and 2029, roughly 90% of SIN substations will reach their short-circuit interruption capacity[10] due to the expected increase in installed power within the system (UPME, 2024c).

The available transmission capacity in the SIN is low, even dropping below 5% in several regions. These limits have been reached because grid expansion is progressing more slowly than demand growth and the progress of new projects, especially FNCER (CREG, 2025c). Over the last three years, the government released nearly 5 GW of connection capacity to the SIN by clearing out projects without real progress, equivalent to 25% of the country's nominal installed power generation capacity (Energía Estratégica, 2025).

According to XM, the Caribbean area, consisting of the Guajira-Cesar-Magdalena and Córdoba-Sucre-Bolívar sub-areas, shows the strongest signs of grid strain (XM, 2023). In this area, 16 restrictions have been declared in an emergency state and 15 in an alert state, and the need for demand disconnection under normal grid conditions has been identified due to overloads on equipment or voltages below 90% of nominal voltage. This situation is exacerbated by the withdrawal of the network operator AFINIA from carrying out projects and works on STR (Nueva Arjona 110/66 kV, Nueva Magangué 500/110 kV, and Nueva Sahagún 500/110 kV), creating uncertainty regarding supply reliability in the area (XM, 2025).

Other operational areas of the SIN, such as the Eastern and Southwestern regions, also exhibit limitations in inter-area transfer capacity, exposing consumers to the risk of unmet demand (blackouts), operational cost overruns due to the need to bring online expensive local power plants, and vulnerability to faults (XM, 2025).

10 It is the nominal exceeding of the fault current ratings for the interruption equipment at the substations. According to the technical criteria defined by UPME, XM and CNO, a substation is considered exhausted when the maximum short-circuit current level is greater than or equal to 90% of its interruption capacity.

In response to these challenges, UPME drew up a strategic portfolio of 98 projects to enable the modernization of the SIN, of which 38 address the issue of low short-circuit capacity – also referred to as "normalization projects" – and 21 projects aimed at improving transmission capacity, including optimization works, HTLS[11] repowering, and structural expansions (UPME, 2024b). To implement these improvements, UPME and sector stakeholders require regulatory solutions and expedited mechanisms that incentivize these investments.

5. Reflections and perspectives

Colombia faces a historic challenge: bringing online around 18 GW of generation projects with assigned transmission capacity by 2030 – mostly Non-Conventional Renewable Energy Sources (FNCER) – into a transmission system whose expansion is progressing at a slower pace than required. To achieve this, the country must overcome operational constraints by prioritizing execution of at least 44 of the 98 National Interconnected System (SIN) expansion projects by 2034, as proposed in the Master Plan (UPME, 2024b).

This is an unprecedented challenge for the institutions and stakeholders involved, as it entails coordinating the development of 98 projects in less than 10 years against a backdrop of operational constraints and delays in the commissioning of new transmission projects. This requires not only greater institutional capacity but also new forms of inter-institutional coordination, planning, and management of electrical infrastructure development. The Territorial Engagement Model for the sector planning emerges as a key element and must move from a theoretical and diagnostic phase to a stage of adoption, capacity building, and continuous improvement in an accelerated manner (UPME, 2022).

Furthermore, the widespread electrification of sectors such as transportation and industry is driving a structural transformation of energy demand. Projections from the National Energy Plan (PEN) indicate that by 2052, Colombia must have a transmission grid capable of transporting three to five times the current electricity supply, with demand set to reach between two and five times today's levels (UPME, 2024d). To sustain this growth and advance toward carbon neutrality by 2050, the system will require approximately 50 000 km of additional transmission lines – extending the total to nearly 80 000 km – along with new associated infrastructure such as substations, transformers, interconnections, and compensation devices (IEA, 2025).

The expansion and modernization of the SIN is not merely a technical condition for the entry of the new generation; it is a decisive pillar for ensuring a reliable and socially accepted energy transition, capable of responding to both climate commitments and the country's development. Failure to properly address these needs will hinder the integration of generation projects and expose consumers to the risk of service disruptions.

11 High-temperature, low-sag conductors

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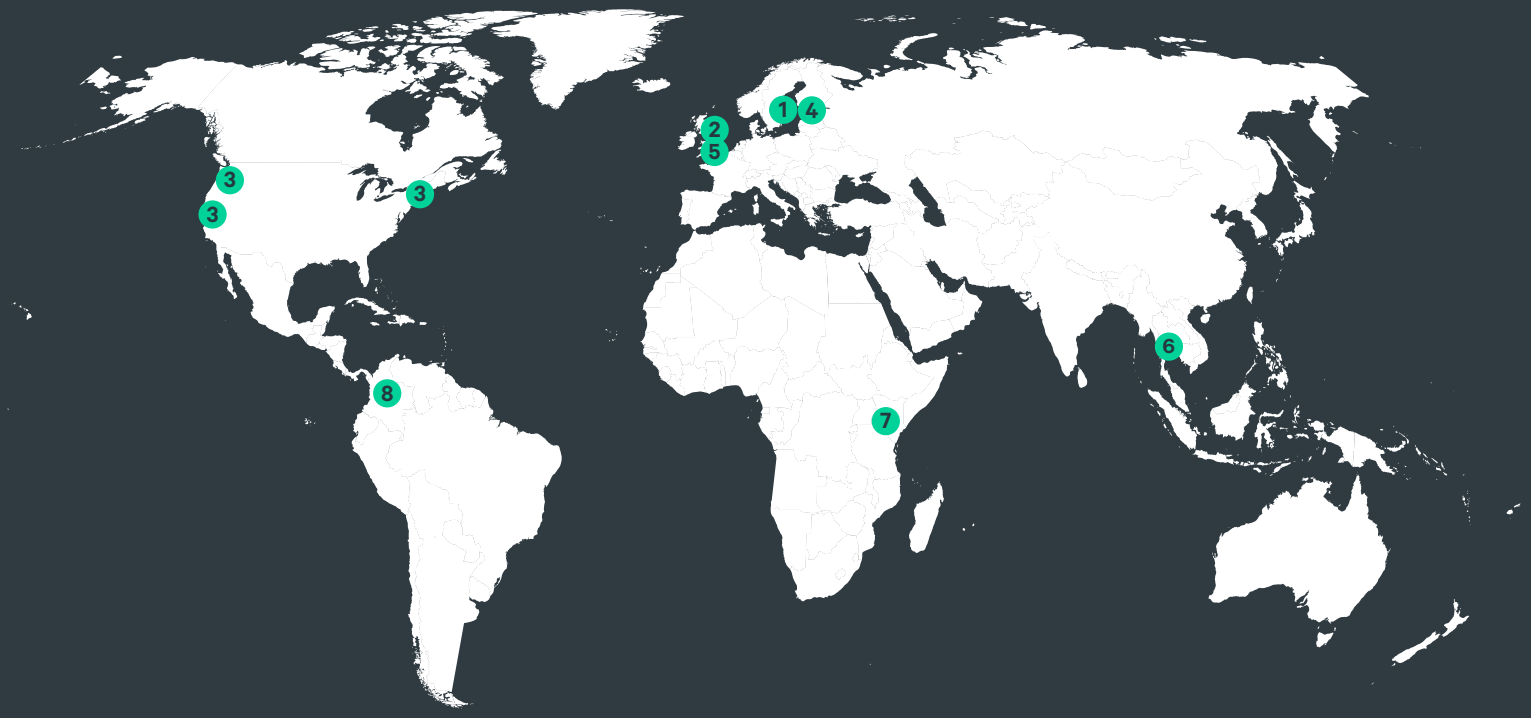

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