TELECOMMUNICATIONS NETWORKS STRUCTURAL PLAN – PERT

2025 - 2029

Anatel's regulatory plan for the expansion of Universal and Meaningful Connectivity in Brazil.

ANATEL/2025

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2025 - 2029

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ABBREVIATIONS AND ACRONYMS

2G	SECOND GENERATION MOBILE TECHNOLOGY
3G	THIRD GENERATION MOBILE TECHNOLOGY
4G	FOURTH GENERATION MOBILE TECHNOLOGY
5G	FIFTH GENERATION MOBILE TECHNOLOGY
ANATEL	NATIONAL TELECOMMUNICATIONS AGENCY
CMR	WORLD RADIOCOMMUNICATIONS CONFERENCE
CIS	COMMONWEALTH OF INDEPENDENT STATES
DTH	DIRECT TO HOME
BTS	BASE RADIO STATION
FISTEL	TELECOMMUNICATIONS INSPECTION FUND
FTTC	FIBER TO THE CABINET
FTTH	FIBER TO THE HOME
FTTP	FIBER TO THE PREMISES
FUST	TELECOMMUNICATIONS UNIVERSALIZATION FUND
HTS	HIGH THROUGHPUT SATELLITES
IBGE	BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS
ICMS	TAX ON THE CIRCULATION OF GOODS AND SERVICES
IPEA	INSTITUTE OF APPLIED ECONOMIC RESEARCH
INEP	NATIONAL INSTITUTE FOR EDUCATIONAL STUDIES AND RESEARCH ANÍSIO TEIXEIRA
IOT	INTERNET OF THINGS
LDCs	LEAST DEVELOPED COUNTRIES
LGT	GENERAL TELECOMMUNICATIONS LAW
MCICT	MINISTRY OF SCIENCE, TECHNOLOGY AND COMMUNICATIONS
MD	MINISTRY OF DEFENSE
MEC	MINISTRY OF EDUCATION
MS	MINISTRY OF HEALTH
PBLE	BROADBAND IN SCHOOLS PROGRAM
PGMC	GENERAL COMPETITION GOALS PLAN
PGMU	GENERAL PLAN OF UNIVERSALIZATION GOALS
PI-RNP	RNP INTERMINISTERIAL PROGRAM
PMS	SIGNIFICANT MARKET POWER
PNBL	NATIONAL BROADBAND PLAN
PPDESS	PUBLIC PRICE FOR GRANTING THE RIGHT TO OPERATE SATELLITES
RNP	NATIONAL RESEARCH NETWORK
SCM	MULTIMEDIA COMMUNICATIONS SERVICE
SEAC	CONDITIONAL ACCESS SERVICE
SEI	ELECTRONIC INFORMATION SYSTEM
SGDC	GEO-STATIONARY SATELLITE FOR DEFENSE AND STRATEGIC COMMUNICATIONS
SMP	PERSONAL MOBILE SERVICE
STFC	FIXED SWITCHED TELEPHONE SERVICE
TAC	TERMS OF ADJUSTMENT OF CONDUCT
ITU	INTERNATIONAL TELECOMMUNICATION UNION
URA	AUDIBLE RESPONSE UNIT

1. Introduction

Amid the accelerated transition to a predominantly digital age, a country's telecommunications infrastructure emerges as a vital component for its economic, social, and technological advancement. The Telecommunications Network Structural Plan (PERT) was designed with the mission of providing a comprehensive overview of telecommunications connectivity in Brazil. This diagnosis is crucial because only by recognizing and understanding the gaps in our infrastructure can we formulate strategies to overcome them. Therefore, it is imperative to identify where these gaps are, who is most impacted by them, and what the underlying causes are.

This study aims to shed light on various dimensions of connectivity in the country, thus guiding the formulation and implementation of public policies that aim to universalize and improve access to broadband Internet. In this chapter, we will present the trajectory of the PERT, the current state of connectivity in light of the guidelines of the International Telecommunication Union (ITU), and the strategic role played by Anatel in this context.

A brief history of the PERT

Based on the General Telecommunications Law (LGT) and the Agency's Strategic Planning, the President of Anatel, through Board Decision No. 4 of January 9, 2017, determined the submission of the Structural Plan for Telecommunications Networks to the Board of Directors. At that time, the plan's objectives were:

- To diagnose the situation at the time regarding broadband internet access in Brazil;
- To obtain a clear view of the service and infrastructure gaps that impacted the expansion of broadband services;
- To identify areas with low economic viability;
- To propose projects that would stimulate the construction of the necessary infrastructure for the expansion of broadband networks;
- To propose the development of a national plan that would promote the expansion of access to broadband services;
- To identify sources of financing that would enable investments in areas with low market attractiveness.

As approved, the PERT receives annual updates to its diagnostic data and five-year reviews, which aim to adapt the plan to all updates in the sector, which by its nature is constantly evolving. In this review process, there was a profound awareness within the Agency regarding the changes in the global telecommunications landscape. In particular, this work sought to align with the emerging concept of "universal and meaningful connectivity," as defined by the International Telecommunication Union (ITU).

Connectivity, in its traditional form, simply measures access. However, "meaningful connectivity" goes further and considers the quality, relevance, availability, and security of the connection. In this sense, simply being online is not enough, it is essential that access allows for productive, secure, and relevant engagement with cyberspace. Thus, this PERT review focused not only on diagnosing the need to expand network infrastructure, but also on diagnosing whether the

connectivity provided is truly meaningful, offering people more robust tools to interact with the digital age in a full and enriching way.

Current context of universal and meaningful connectivity

In an increasingly connected world, data and information are accessible in real time from virtually anywhere on the globe, presenting a new dynamic to the relationships between people, governments, and economies. As the ITU has rightly pointed out, denying a large segment of the population the opportunities provided by the Internet results in costly consequences, exacerbating inequalities and hindering progress. In three decades, we have witnessed an extraordinary leap, from a mere million to 5.3 billion internet users. However, much of the internet's beneficial potential, both socially and economically, has not yet been fully exploited: one in three individuals in the world still does not have access to it, and a large portion of these users only have basic connectivity. We still find wide digital disparities, whether between nations, genders, generations, or between urban centers and rural regions, as well as between those with access to cutting-edge technologies and those who make do with patchy 3G connections. The new challenge is to achieve Universal and Meaningful Connectivity (UMC).

For connectivity to have a truly transformative impact on our society and economy, it needs to be not only comprehensive, but also meaningful and effective. This concept can be visualized along two main axes: breadth of use and quality of connection.

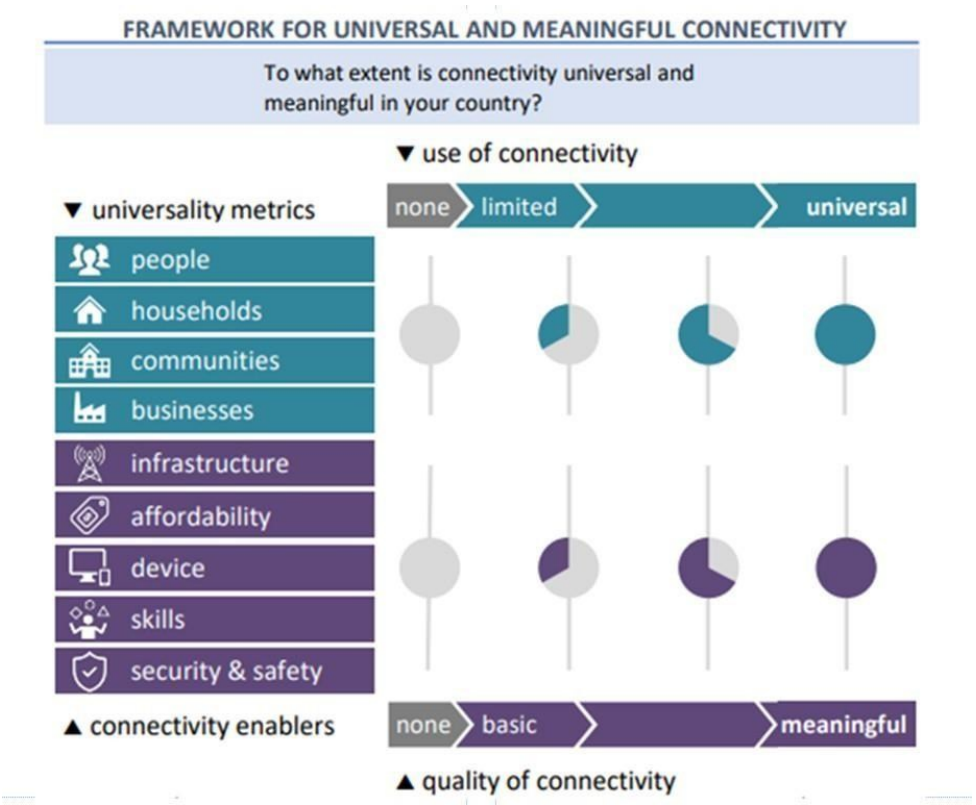
The idea of "universal connectivity" translates to guaranteeing access for everyone. "Meaningful connectivity", on the other hand, refers to the ability to provide users with an enriching, secure, and efficient online experience at an affordable cost. Both dimensions complement each other: it is no use having ubiquitous but ineffective connectivity, just as it is no use having excellent connectivity that is not accessible to everyone. Naturally, both reinforce each other: the greater the use, the greater the chance of a richer online experience. Hence the concept of Universal and Meaningful Connectivity.

Universal and Meaningful Connectivity

In this new approach, connectivity and digital inclusion are evaluated from two complementary dimensions. The metric used for **universal connectivity** is quantitative and focuses on the availability and use of Information and Communication Technologies (ICT) by citizens, households, businesses, and communities. **Meaningful connectivity**, on the other hand, is measured by the quality of its enablers.

Brazil is at a strategic juncture to boost its digital transformation, which can generate significant opportunities in various areas, such as education, health, agriculture, and the creative economy. Expanding meaningful connectivity is an essential factor for digital inclusion and for reducing regional disparities, creating an environment conducive to the emergence of new business initiatives, the development of digital skills, and the strengthening of the digital economy. As more Brazilians gain access to high-quality internet, the country is also positioning itself to face global challenges in a more competitive and resilient way.

Figure 1: ITU framework for universal and meaningful connectivity



Source: ITU, 2022.

The ITU reference framework (Figure 1) lists five enablers of meaningful connectivity, namely: availability and quality of mobile and fixed networks (infrastructure), affordability of services and Devices (affordability), access to devices (device), digital skills/abilities (skills), and security of connection and browsing (security and safety) (ITU, 2022)[12].

Combining these two pillars, it becomes clear that it is not enough for connectivity to be available to everyone (universal), it also needs to allow users a complete, satisfying, enriching, and secure online experience at an affordable cost (ITU, 2023)[3].

This new version of the PERT will address in the following chapters all the dimensions mentioned in the ITU framework for universal and meaningful connectivity.

Anatel's strategic plan

Anatel, as the telecommunications regulator in Brazil, plays a crucial role in achieving the objectives of the PERT and adapting to international standards and guidelines, such as those established by the ITU. Its mission is not limited to simply implementing and monitoring connectivity policies, but also to ensuring that the country's telecommunications infrastructure and services are of high quality, accessible, and aligned with the needs of citizens. The Agency is dedicated to establishing partnerships,

[1] **INTERNATIONAL TELECOMMUNICATION UNION. Achieving universal and meaningful digital connectivity.**

[2] **. Available at: <link>.**

[3] **. Aspirational targets for 2030. 2023. Available at: <link>.**

fostering investment, and promoting innovation in the sector, always seeking to improve access and the experience of Brazilian users in the digital age.

In general terms, strategic planning is an essential process for guiding an organization's direction, its purpose, the values it cultivates, its reason for existing, where it wants to go, and the expected results. Its final product is the strategic plan, which establishes strategic objectives and performance targets aimed at effectively fulfilling the organization's mission and its vision for the future.

Anatel's Strategic Plan for the period 2023 to 2027 is structured around strategic objectives, goals, and initiatives, focusing on results aimed at promoting internet connectivity, developing dynamic markets, and providing quality communication services for all. It thus contains the foundations for the Agency's regulatory activities and is aligned with the main government planning instruments, such as the Multi-Year Plan (PPA) for the four-year period from 2024 to 2027, established by Law No. 14,802 of January 10, 2024, the Federal Development Strategy for Brazil (EFD), established by Decree No. 10,531 of October 26, 2020, and public policies for the telecommunications sector.

The Agency aims to be recognized as an independent and impartial institution that contributes to the country's **digital transformation** and regulates the sector for the benefit of society, making the market dynamic, attracting and expanding investments, and ensuring the quality of services offered to all.

Connecting Brazil to improve the lives of its citizens is the purpose contained in the Strategic Plan and is linked to connectivity in Brazil. The impact of its actions is to contribute to improving the lives of Brazilians, with regulation being an instrument that will support this progress.

The definition of Anatel's new strategic positioning and target scenario for 2027 is based on two key dimensions: promoting supply (accessibility) and promoting demand (pace of digitization).

Through the implementation of the Plan, the aim is to place Brazil among the most digitally developed countries, the so-called G20 Digital (where it is currently in 54th position, according to the Global Innovation Index[4]). That is, it means transforming Brazil into a country that develops its full socio-economic potential with a strong digital economy and a dynamic market in terms of both supply and demand.

Strategic Objectives and Goals

The document defines four outcome objectives for the coming years, which encompass the Agency's ultimate goals, understood as those aimed at delivering public value to society and aligned with legal requirements and current public policies.

Methodologically, strategic goals were established: predictive and influenceable guiding measures aimed at translating into an expected result, that is, the public value that Anatel will generate and deliver to society as a result of fulfilling its strategic objectives.

To facilitate understanding by the public, a goal is constructed through predictive and influential action to leverage the result (translation of the strategic objective), the indicator that reflects

[4] https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-section3-en-gii-2022-results-global- innovation-index-2022-15th-edition.pdf

current performance and where one wants to be in the future (historical measure), and the timeframe in which it will be achieved (time).

Below are listed the 13 strategic goals established to be achieved by 2027, in accordance with the strategic outcome objectives of the Plan:

Objective 1 - To promote connectivity and the provision of quality communication services for all

- Goal 1: Expand 5G-SA mobile coverage from 0% in 2021 to 57.67% of the Brazilian population by 2027;
- Goal 2: Expand fiber optic backhaul connectivity from 76.92% to 100% of Brazilian municipalities by 2027;
- Goal 3: Expand fiber optic backhaul connectivity from 13.63% to 50% of locations with more than 600 inhabitants by 2027.
- Goal 4: Increase the average contracted speed in fixed broadband from 186.3 Mbps to 1 Gbps by 2027.
- Goal 5: Increase compliance with contracted download speeds from 78.28% to above 87% by 2027.
- Goal 6: Increase the overall satisfaction level of Fixed Broadband consumers from 6.9 to 7.5 by 2027.
- Goal 7: Raise the overall satisfaction level of mobile phone consumers from 7.6 to 8.1 by 2027.

Objective 2 - To stimulate dynamic and sustainable markets for communication and connectivity services

- Goal 8: Maintain aggressive market competition for fixed broadband supply until 2027.
- Goal 9: Maintain market competition in the mobile telephony supply market in a conservative scenario until 2027.

Objective 3 - To foster digital transformation within society under conditions of market equilibrium

- Goal 10: Contribute to increasing the percentage of Internet users in Brazil in order to keep it comparable to the top 20 countries ranked by the International Telecommunication Union (ITU) by 2027.
- Goal 11: Contribute to expanding the percentage of Internet users in Brazil with moderate skills in information and communication technologies (ICT) in order to keep it comparable to the 20 best-rated countries by the International Telecommunication Union (ITU) by 2027.

Objective 4 - To guarantee excellent performance with a focus on results for society Market dynamism axis

- Goal 12: Improve the level of governance and management of Anatel to be comparable to the 20 best-rated bodies and entities in the Federal Public Administration by 2027.
- Goal 13: Increase the availability of Anatel's data and information in open format from 21.9% to 85% by 2027.

Objectives of Processes and Thematic Axis

- There are also 15 process objectives that unfold and detail the strategic outcome objectives for better directing the Agency's actions, divided into four major thematic axis: infrastructure and quality; market dynamism; modernity, digital transformation, innovation and society; and internal management.

Axis 1 - Infrastructure and Quality

- It is considered that the country's digital transformation will only be achieved satisfactorily if it is universal. Therefore, the Agency must do everything in its power to guarantee the universality and quality of communication services.
- A high-capacity and fast infrastructure promotes social and economic progress, and therefore, a commitment to **service quality** is fundamental for a better user experience.
- The standards of excellence expected from new uses of connectivity will be significantly higher than current ones, requiring continuous quality assurance to ensure **user satisfaction**, according to the specific characteristics of the service and the region served, with adequate connection and capacity to meet their needs.

Axis 2 - Market Dynamism

- It is understood that, in order to attract the substantial investments necessary for **Brazil's digital transformation**, it will be necessary to ensure **economic sustainabili**ty in all links of the **connectivity** production sector's value chain to enable its long-term development.
- Thus, Anatel's role is strategic in fostering **dynamic and competitive markets** in the connectivity sector. By ensuring equitable access and regulation for providers, healthy competition is promoted, stimulating innovation and improving the quality of services.
- For example, competition leads to more efficient use of scarce resources, such as spectrum, and attracts investors due to greater predictability and regulatory security.

Axis 3 - Digital Transformation, Innovation and Citizenship

With the changing connectivity landscape around the world, where digital platforms and ecosystems are gaining increasing relevance in the lives of individuals and businesses, Anatel will seek to be proactive in developing the sector, reflecting a more convergent environment, and will ensure a balance between the supply and demand of connectivity.

To that end, the Agency will drive **Brazil's digital transformation** through actions promoting **meaningful and universal connectivity** aimed at the digital inclusion of people and raising the level of knowledge of digital users for the proper use of technology and for understanding its benefits and risks.

Axis 4 – Excellence in Management

Ensuring **excellent performance** focused on results and effectiveness is the key enabler for Anatel to achieve its strategic goals and objectives of promoting quality connectivity, stimulating dynamic and sustainable markets, and fostering the country's digital transformation.

Excellence should permeate all of the Agency's activities and will be enhanced through: (i) **continuous training** of its employees; (ii) **productivity** in a healthy work environment, capable of

motivating, developing and retaining talent; (iii) **efficiency** in the application of public resources; (iv) **good governance**, diligent in ensuring transparency of regulatory information and results obtained; (v) **timely communication** with society; and (vi) **agility and speed** in the execution of activities and deliveries to the citizen, facilitated by the use of state-of-the-art information and communication technologies.

Strategy Execution

The unfolding of the Strategic Plan, that is, its execution, is carried out through Tactical Management Plans (TMPs), developed in accordance with the public policies established by the Executive and Legislative branches, aimed at the telecommunications sector, in compliance with the Law of Regulatory Agencies and aimed at overcoming the challenges and opportunities within a two-year time horizon, with annual reviews, in order to enable the continuity and fluidity of the Agency's regulatory and management actions.

The TMP brings together the priorities for the two-year period of its validity, materialized in tactical goals focused on the strategic process objectives for the reference period of the management cycle. The document synchronizes, aligns, and directs the Agency's main institutional plans (tactical initiatives) and indicates the most relevant proposals for action in the business processes of Anatel's Value Chain environments: Governance, Relationship and Communication, Regulation and Management, and Support.

Strategic Program for Meaningful Connectivity

The Strategic Program for Meaningful Connectivity, part of Anatel's Strategic Plan, is a fundamental milestone in Brazil's digital transformation agenda. This program aims to ensure that connectivity in the country is not only universal but also meaningful, prioritizing quality, accessibility, and relevance in internet use by all citizens.

With a comprehensive approach, the program encompasses initiatives aimed at expanding network coverage, increasing service quality, promoting consumer transparency, and encouraging digital literacy. It also seeks to ensure trust in the digital environment through anti-fraud measures and the strengthening of monitoring mechanisms and infrastructure sharing.

The main objectives include:

- **Improving** fixed and mobile network **infrastructure**, promoting coverage in rural areas, remote locations, and regions with low economic attractiveness.
- **Strengthening the quality and competitiveness** of broadband services, ensuring transparency and reliability for consumers.
- **Promoting digital inclusion**, with a focus on accessibility to devices and the development of digital skills.
- **Trust and security**, reducing fraud and strengthening security in the digital ecosystem.

Among the program's main deliverables are an updated diagnosis of network infrastructure, methodologies for evaluating service quality, and awareness campaigns for the safe and responsible use of the internet. The program foresees integrated actions, reinforcing its commitment to reducing regional inequalities and promoting equitable access to connectivity in Brazil.

PERT as an Instrument for Achieving the Effectiveness of Sustainable Development Goals

The PERT presents a general diagnosis of Brazil's telecommunications infrastructure. The instrument focuses on structural deficiencies related to transport and access networks that enable mobile and fixed broadband services regulated by Anatel. In this sense, the importance of the instrument can be observed from its relationship with the effectiveness of the Sustainable Development Goals (SDGs) established by the 2030 Agenda within the framework of the United Nations (UN).

The 2030 Agenda embodies the cooperative effort of the international community to observe a list of tasks that governments, the private sector, and organized civil society can adopt as a reference for achieving sustainable development. The Agenda lists 17 SDGs and 169 targets to be achieved by 2030 by 193 countries.

In Brazil, public administration bodies and entities at all three levels of government have been making efforts to give effect to the SDGs through actions aimed at: eradicating poverty, guaranteeing rights and gender equality, promoting the use of energy and sustainable production and consumption patterns, combating climate change, enabling inclusive economic growth, among others. In its role as the regulatory agency for telecommunications services, Anatel has been making efforts to contribute to the effectiveness of the SDGs through internal actions, promotion of the sector, and institutional dialogue.

The regulation of telecommunications services carried out by the Agency is directly related to the 2030 Agenda, particularly SDG 9. This Goal has as its central theme "building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation". On the other hand, the good regulatory practices adopted by Anatel foster the expansion of telecommunications infrastructure and generate a multiplier effect on other SDGs. For example, consider SDG 4 (Quality Education) when meaningful and universal connectivity is promoted.

By working to "significantly increase access to information and communication technologies" (SDG 9 target 9.c), Anatel reaffirms its purpose of connecting Brazil to improve the lives of its citizens. This demonstrates concrete actions that generate benefits for consumers, society, the sector, and the Digital Ecosystem itself. The PERT is one of the instruments that demonstrates these actions and the stated purpose.

Sustainable development encompasses three important dimensions: social, economic, and environmental. For telecommunications services to be sustainable and promote sustainability, these dimensions must be considered in daily practices. It is precisely from this perspective that Anatel has been working since the first publication of the PERT.

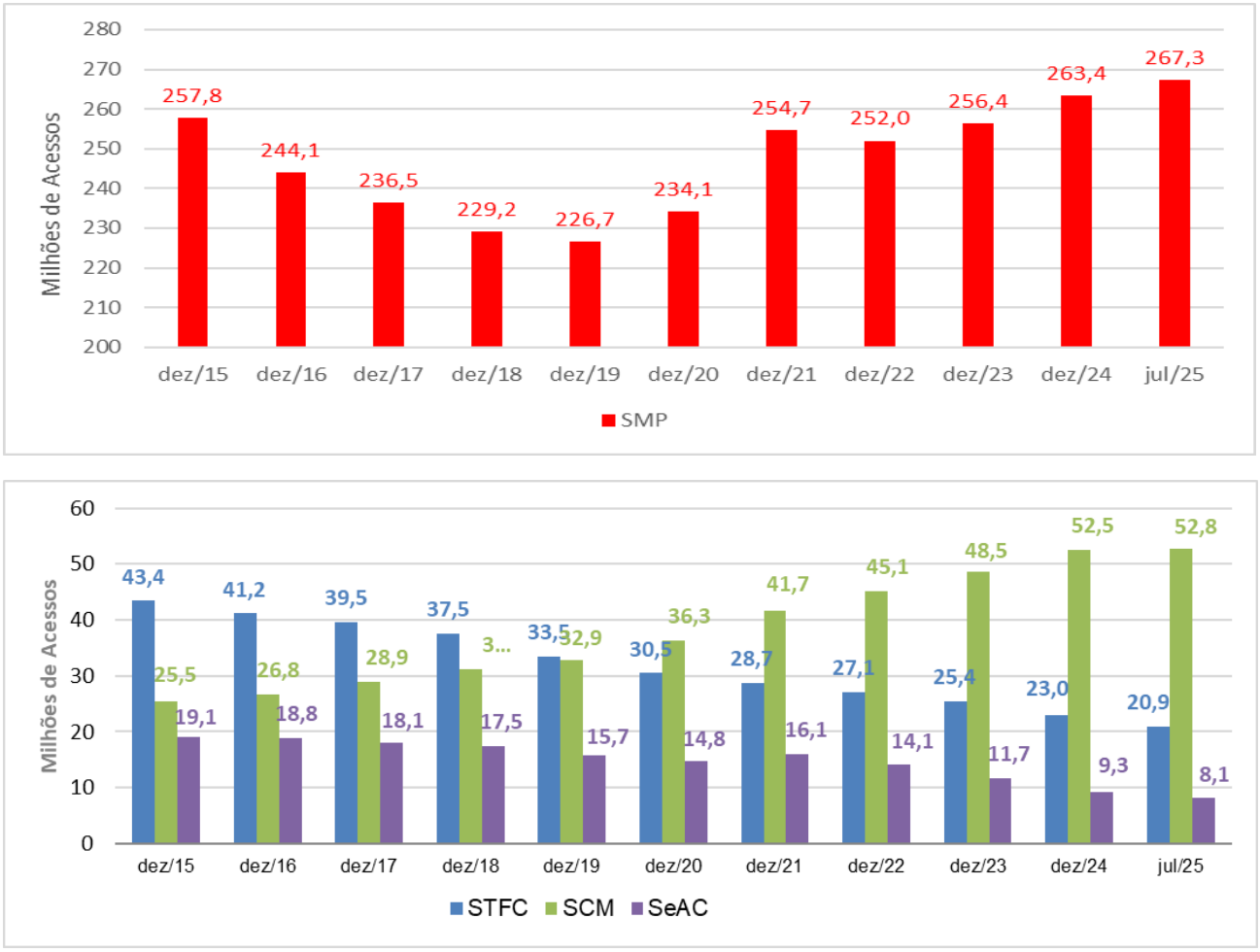
2. Infrastructure

This chapter presents the current diagnosis of telecommunications networks in Brazil, with special emphasis on the support networks for fixed and mobile broadband Internet access services. It highlights the service level, access trends, mobile coverage, transport and access infrastructure (mainly fiber optics), average speed, and other data. It is noted that when referring to mobile broadband networks, the focus is on supporting Personal Mobile Service (SMP) networks, while fixed broadband networks refer to Multimedia Communication Service (SCM).

Overview of Network Infrastructure

Within the scope of Anatel, information is received monthly regarding the number of accesses (subscribers) per existing service, namely, SCM (Fixed Broadband), SMP (Mobile Telephony), STFC (Fixed Telephony) and SeAC (Pay TV Services), among the various telecommunications service providers. By consolidating the sector data, we can see the evolution of access to the main telecommunications services, with emphasis on internet connection services: Multimedia Communication Service (SCM) and Personal Mobile Service (SMP):

Figure 2: Evolution of Accesses by Service



Source: Anatel Data Panel

In 2020, for the first time, the number of SCM accesses surpassed those of STFC, indicating the decreasing use of landline telephony and the significant increase in fixed internet access, driven by the popularization of remote work and online services, a trend that continued in subsequent years.

Another relevant fact was that, when evaluating the evolution of SMP accesses by billing method, from 2020 onwards in the computed series, the number of postpaid accesses exceeded the number of prepaid accesses (which also includes corporate accesses).

Despite the consistent growth in access to all telecommunications services over the years, the largest share is concentrated in the Southeast region of the country, the most populous..

Table 1: Number of Accesses per Service

REGIÃO	STFC	SCM	SMP	SEAC
Brasil	20.931.545	52.783.426	267.263.685	8.115.519
Região Centro-Oeste	1.527.787	3.891.432	20.501.398	404.595
Região Nordeste	1.873.397	8.900.275	56.413.521	1.282.505
Região Norte	886.249	2.735.486	17.714.665	319.594
Região Sudeste	12.762.906	26.880.943	133.786.665	5.065.129
Região Sul	3.881.206	10.375.290	38.847.436	1.043.696

Source: Anatel Data Panel (July/2025)

As can be seen in the table below, the density of services is still quite uneven across the country's regions. The Southeast region has the highest density of telecommunications access, except in the case of SCM, where the South region has the highest density. The lowest rates are found in the North and Northeast regions.

Table 2: Density[5] per Service

REGIÃO	STFC	SCM	SMP	SeAC
Brasil	9,8	24,8	101,8	3,8
Região Centro-Oeste	8,9	22,8	107,0	2,4
Região Nordeste	3,3	15,6	89,7	2,2
Região Norte	4,7	14,7	86,4	1,7
Região Sudeste	14,4	30,3	110,6	5,7
Região Sul	12,5	33,3	105,5	3,4

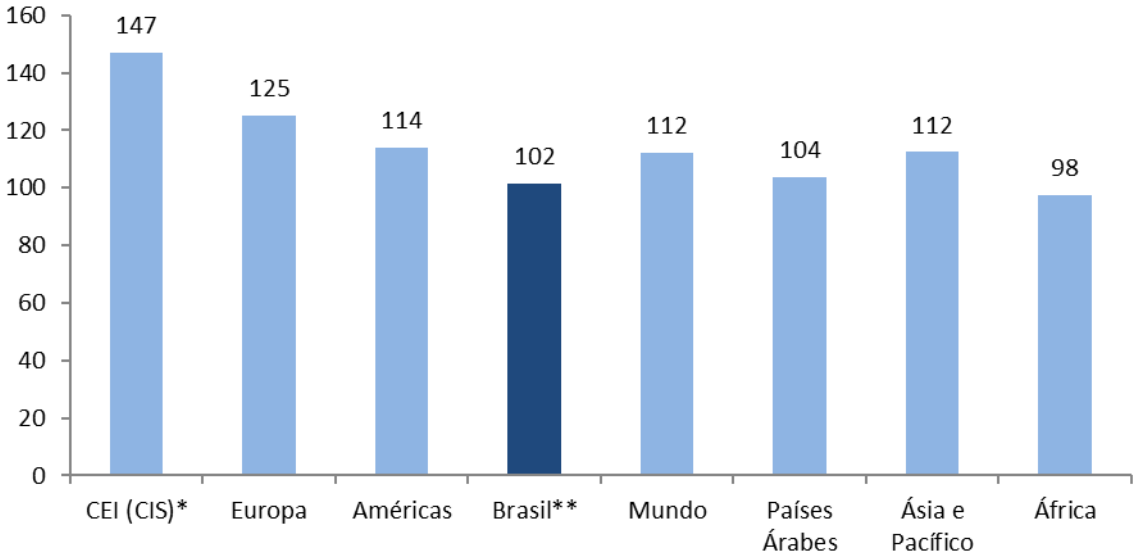
Source: Anatel Data Panel (July/2025)

The data reinforces the disparity in access density to telecommunications services among Brazilian regions. The Southeast stands out with the highest density, driven by favorable economic and population factors. In contrast, the North and Northeast regions face significant challenges, such as geographical barriers and lower economic attractiveness for infrastructure investments. This scenario highlights the need for public policies focused on reducing these inequalities, promoting more balanced access throughout the country.

[5] Access density is calculated by dividing the number of accesses by the population.

Comparatively, Brazil has a mobile phone density close to the world average. The following graph shows a comparison between national and international mobile phone density.

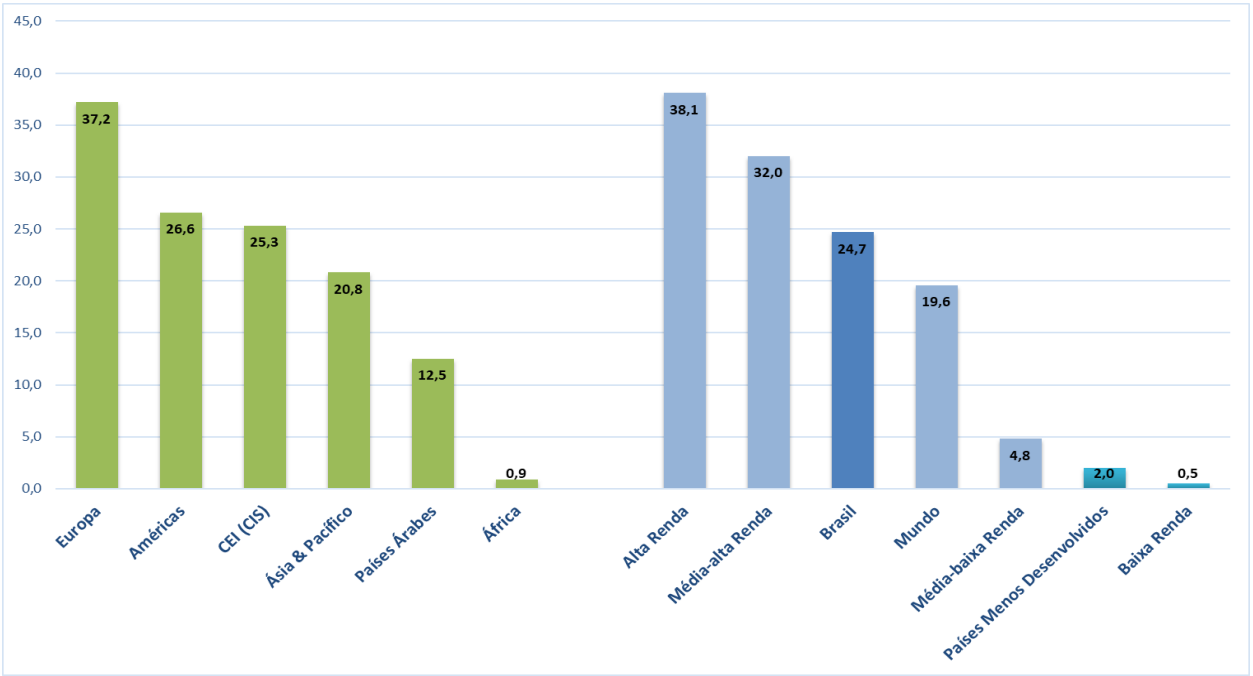
Figure 3: SMP density



Source: Facts & Figures 2024 – ITU / Anatel Data Panel (December/2024).[6]

Regarding fixed broadband penetration, calculated by dividing the number of connections by the population, Brazil is above the world average, but still far behind more developed countries:

Figure 4: SCM Penetration



Source: Anatel (December/2024) and Facts & Figures 2024 – ITU

[6] * The Commonwealth of Independent States (CIS) is made up of the following countries: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, and Uzbekistan;

** Density data includes standard access data for individuals and legal entities.

Figure 4 illustrates the penetration of Multimedia Communication Services (SCM) in various global regions. It can be observed that Europe leads with a penetration rate of 37.2%, followed by the Americas (26.6%) and the CIS (25.3%). Regions such as Asia & Pacific and the Arab Countries show lower rates, at 20.8% and 12.5%, respectively, while Africa has the lowest penetration at only 0.9%. When classifying by income level, high-income countries show 38.1% penetration, while upper-middle-income and lower-middle-income countries show 32% and 24.7%, respectively. Brazil, in turn, has a penetration rate of 24.7%, above the global average of 19.6%, but still far from the rates observed in high-income countries. Low-income nations and Least Developed Countries (LDCs) show the lowest penetration levels, at 0.5% and 2.0%, highlighting a significant disparity in digital inclusion.

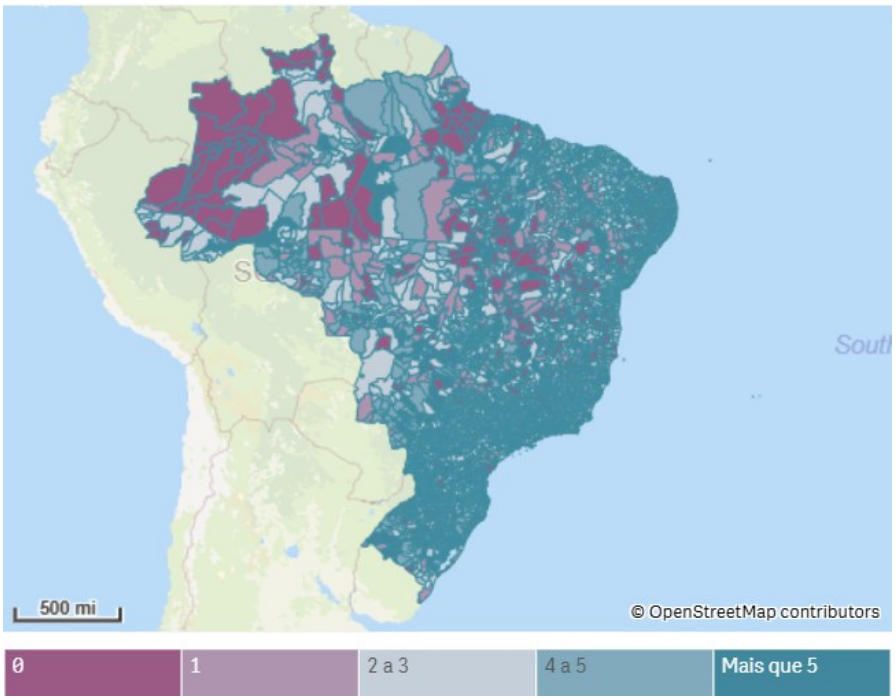
Backbone and Backhaul

The presence of transport network infrastructure is the fundamental aspect for universal and meaningful connectivity, and this network corresponds to what we call backhaul.

In February 2022, a new backhaul data collection system[7] came into effect, applied to all providers with current licenses for any telecommunications services of collective interest, seeking to obtain a complete mapping of the existing transport network in the country.

In 2025, data was collected through the receipt of the configuration of intermunicipal transport networks, in a georeferenced manner and with information on their capacities. This survey revealed that 4,645 municipalities have fiber optic backhaul, which represents approximately 83% of the total number of municipalities.

Figure 5: Fiber backhaul and number of providers



Source: Anatel. Infrastructure Data Panel (2025).

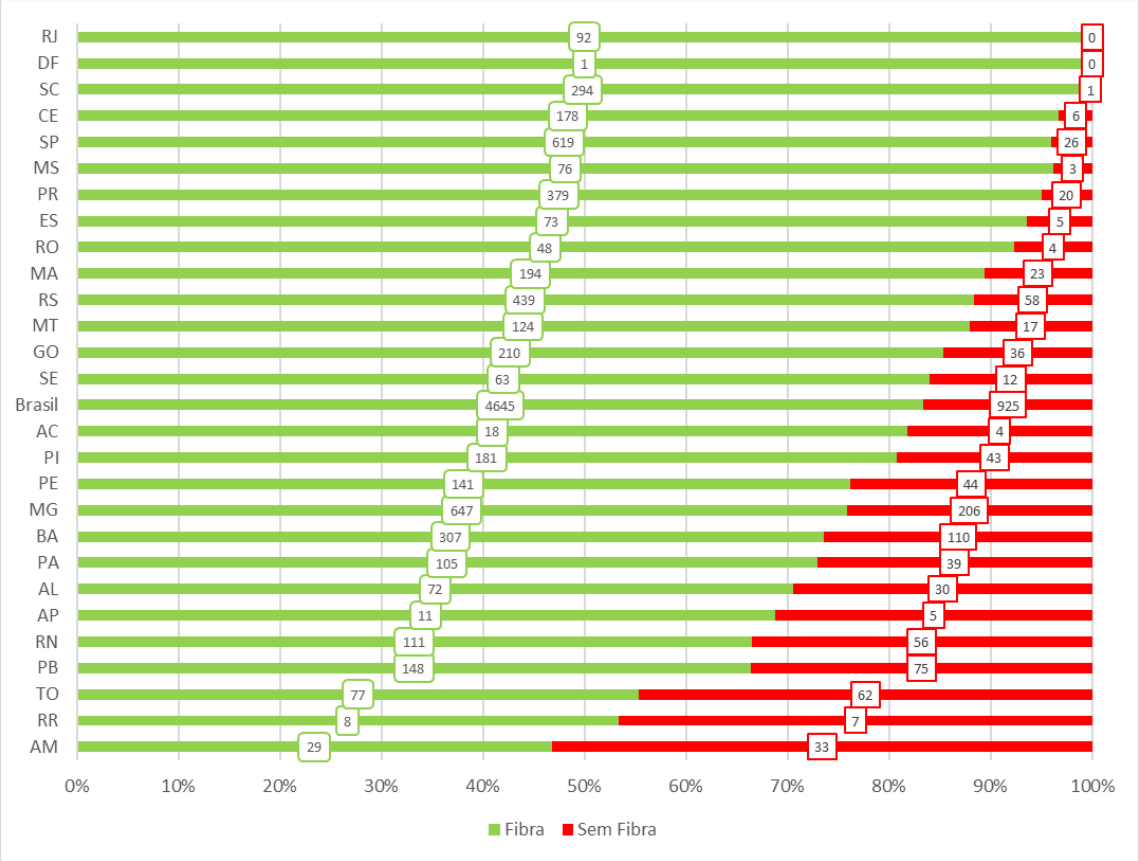
[7] https://www.gov.br/anatel/pt-br/dados/infraestrutura/coleta-de-dados-de-infraestrutura-de-transporte

The map indicates the uneven distribution of fiber optic backhaul in the country, with a greater lack of this infrastructure in the North and Northeast regions:

Region	% municipalities with fiber
North	66%
North East	78%
Southeast	86%
Central-West	88%
South	93%

Regarding the states, a significant gap is noted in the state of Amazonas, with less than 50% of its municipalities connected by fiber optics:

Figure 6: Backhaul of municipalities by state



Source: Anatel. Infrastructure Data Panel (2025)

Therefore, 60% of municipalities without fiber optic internet are located in the North and Northeast regions, and if we also consider the state of Minas Gerais, this percentage rises to 82%.

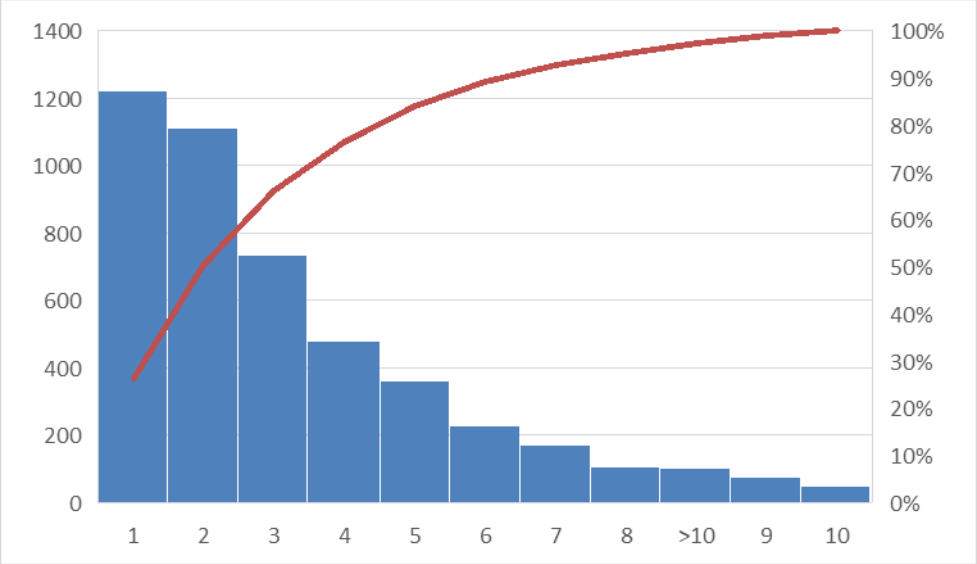
The population residing in municipalities not served by fiber optic backhaul reaches 8,970,651 (4.3%) of the total[8].

[8] **2022 Census IBGE.**

Service Providers

Analyzing the presence of service providers in municipalities with fiber optics, it is noteworthy that 26.3% of municipalities have only one fiber backhaul provider, and of these, 40.9% are in the Northeast region. This finding demonstrates that, despite the large number of broadband internet access service providers in Brazil (more than 20,000), competition in transport is not yet a consolidated reality throughout the country.

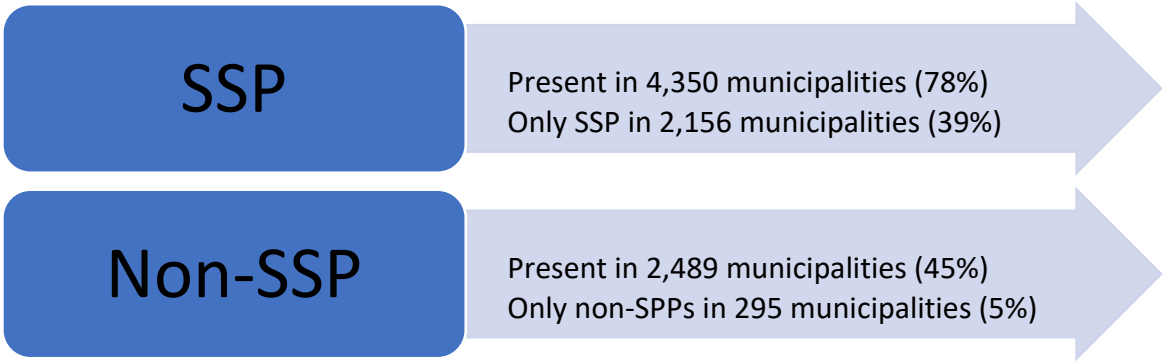
Figure 7: Distribution of municipalities with fiber optic backhaul by number of providers that reported having fiber backhaul



Source: Anatel. Infrastructure Data Panel (2025)

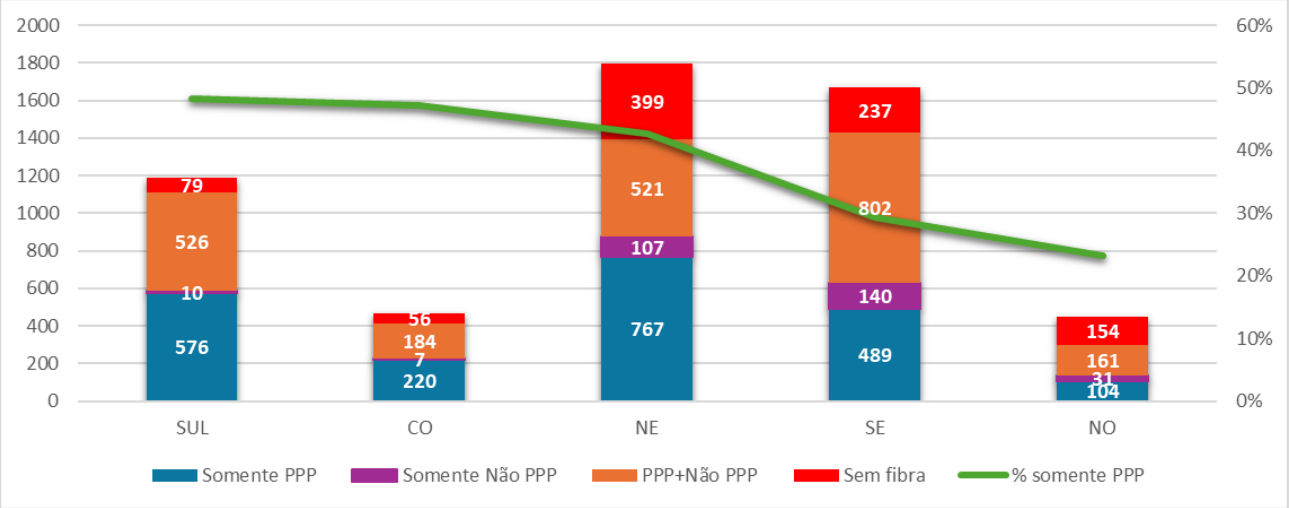
Small Service Providers (PPPs)[9] play an important role in the expansion of fiber optics in the country, increasingly expanding their market share.

Figure 8 highlights the crucial role of Small Service Providers (PPPs) in the expansion of fiber optic backhaul in Brazil. PPPs are present in 78% of municipalities, serving areas often underserved by large operators. With a growing market share, these providers contribute significantly to democratizing access to high-speed internet, boosting local development and reducing regional inequalities.



[9] A small service provider is a group that holds less than 5% of the national market share.

Figure 8: Distribution of municipalities by PPP and non-PPP by region



Source: Anatel. Infrastructure Data Panel (2025).

The significant participation of PPPs in the South, Central-West, and Northeast regions is noteworthy, accounting for 48%, 47%, and 43%, respectively, of the total municipalities served solely by PPPs. These figures corroborate the importance of PPPs in expanding broadband networks in the regions most lacking in this infrastructure.

Locations

In 2021, the Agency collected backhaul data from non-headquarters locations on a case-by-case basis. In this first survey, out of the 16,388 locations mapped by IBGE in the 2010 Census, only 992 were identified as being served by fiber optic backhaul (6.05%). Another 618 locations are served by other transmission methods.

With the goal of improving the mapping and analysis of transportation infrastructure in Brazil, Anatel has initiated a new data collection on backhaul. This collection encompasses detailed information on intermunicipal transportation networks, with georeferenced data and the capacities of existing infrastructures. The process seeks to identify specific gaps, both in municipalities and locations, to support public policies that promote the expansion of meaningful connectivity.

This information will be integrated into Anatel's Infrastructure Panel, contributing to updating the connectivity landscape in the country and increasing the accuracy of the diagnosis regarding the presence of backhaul in urban and rural regions[10].

Gaps

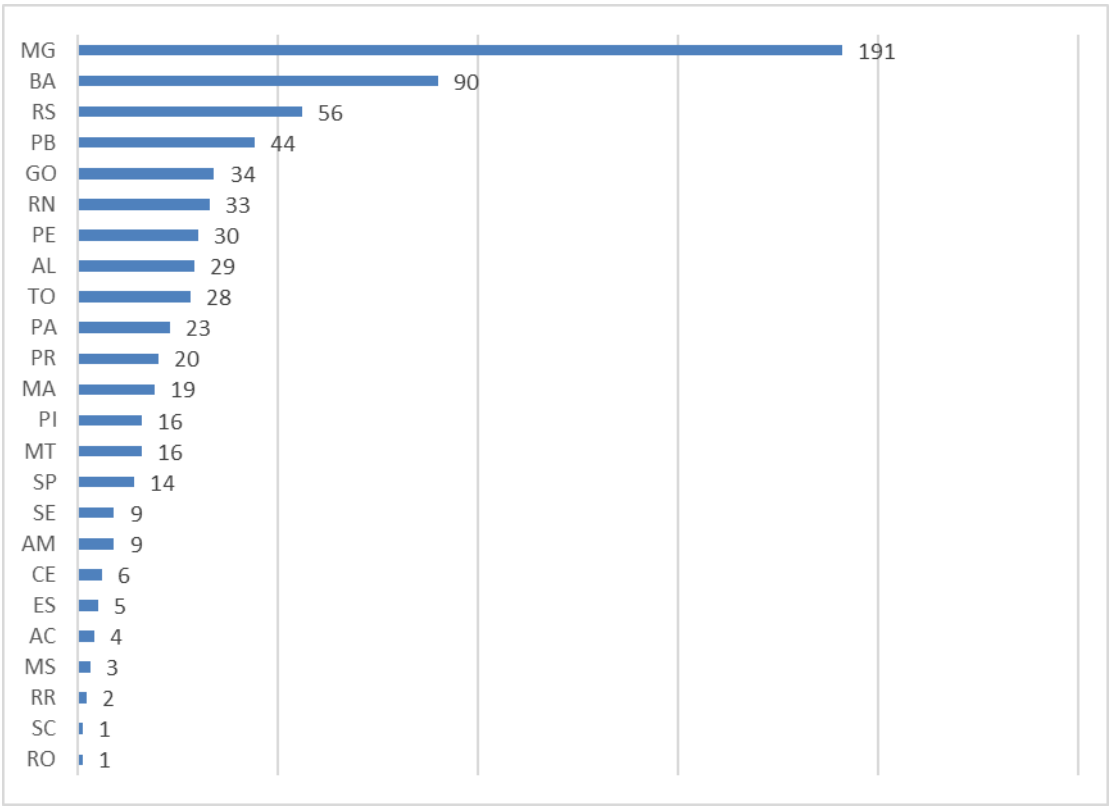
With the obligations for backhaul deployment in the 5G Call for Proposals, Terms of Adjustment of Conduct (TAC) and other instruments[11]there are still 683 municipalities (12%) without fiber optics and without foreseen commitments that should be the target of future public policies. This challenge is concentrated mainly in the Northeast region, which accounts for 40% of these

[10] https://www.gov.br/anatel/pt-br/dados/infraestrutura/coleta-de-dados-de-infraestrutura-de-transporte

[11] https://informacoes.anatel.gov.br/paineis/acompanhamento-e-controle/compromissos-de-investimento

municipalities. It is also worth highlighting the state of Minas Gerais, with 191 municipalities, the highest number among the states.

Figure 9: Distribution of municipalities without fiber optic connections and without commitments by state



Source: Anatel. Infrastructure Data Panel (2025).

Regarding locations, based on currently available mapping, there are 32,458 locations without fiber optic service and without any service obligations. The challenge, therefore, is to improve mapping and expand fiber optic deployment in rural areas, quilombola communities, and indigenous villages.

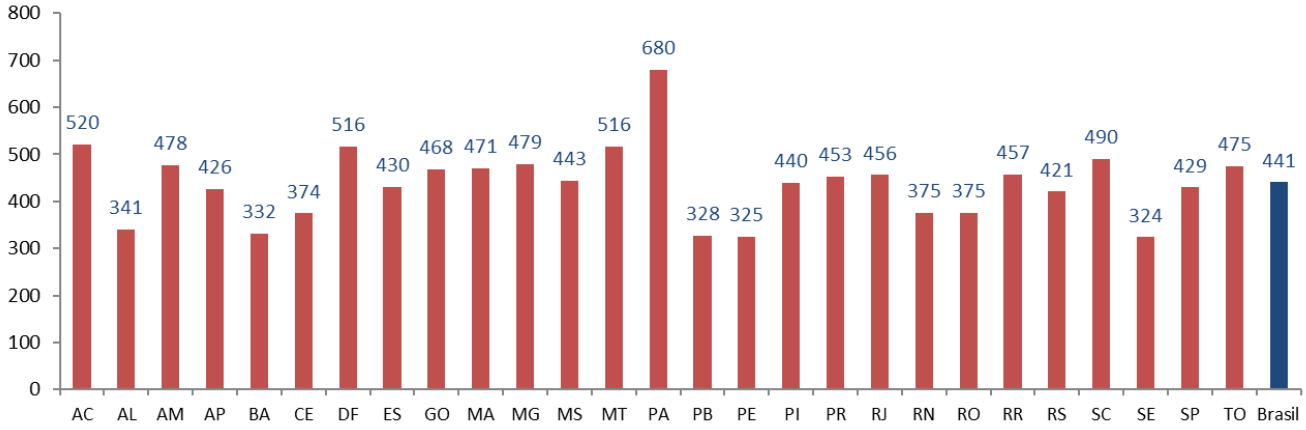
The Integrated and Sustainable Amazon Program (PAIS) plays a key role in advancing telecommunications infrastructure in the Amazon region, helping to mitigate connectivity challenges, especially those related to fiber optic backhaul. The PAIS envisions the deployment of fiber optic routes along the Amazonian rivers, a strategic solution to interconnect municipalities and remote communities, ensuring more robust and comprehensive access. This infrastructure, along with other expansion policies, is crucial to reducing digital divides and promoting digital inclusion in one of the most challenging regions of the country in terms of connectivity.[12]

Speed

[12] https://www.gov.br/casacivil/pt-br/assuntos/noticias/2021/setembro/instituido-o-programa-amazonia-integrada-e-sustentavel

The average contracted speed for fixed broadband service reached 441 Mbps in 2025, according to data from Anatel. It should be noted that this data corresponds to the number of active connections in each speed package sold by companies and not the actual speed transmitted.

Figure 10: Average speed by Federative Unit

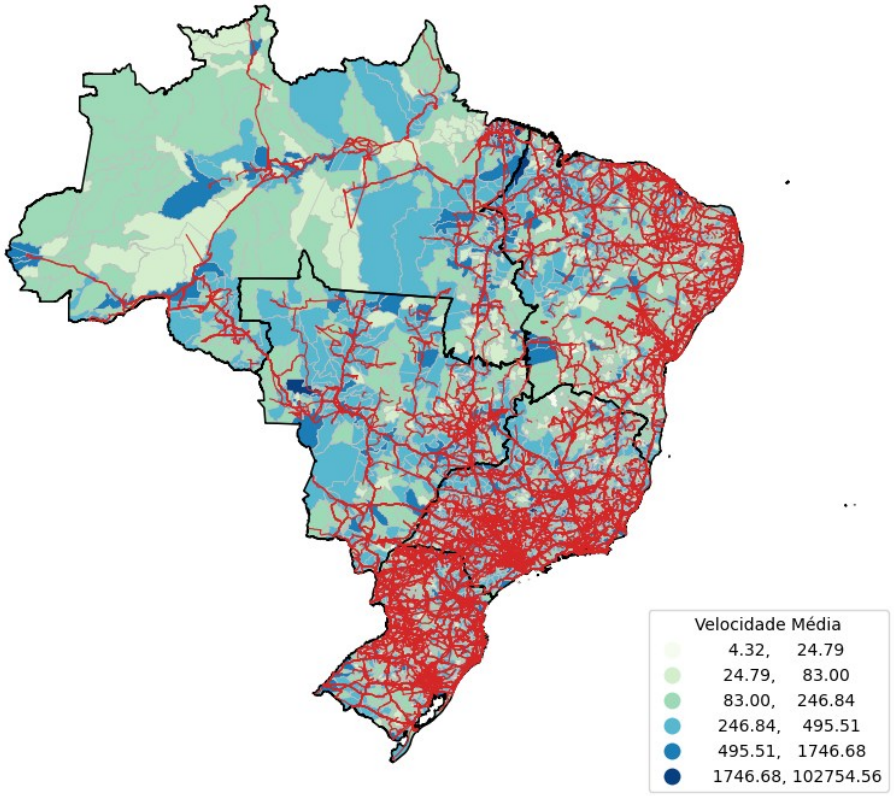


Source: Anatel data panel (June/2025)

The analysis of the speed data above should be carried out considering that states with low service penetration may concentrate access among higher-income classes, resulting in high average speeds. For example, it is observed that some municipalities offer broadband only in wealthier neighborhoods, while the rest of the population lacks access to the service.

The map below shows the direct relationship between the average speed reported by service providers and the existence of fiber optic backbone/backhaul connecting the municipalities. Note that the greener the municipality, the higher the average broadband access speed, and these are the locations where fiber optic backbone/backhaul routes pass.

Figure 11: Speed vs. Fiber Route of the backbone/backhaul (Mbps)



Source: Prepared from data from telecommunications operators (2025).

Challenges

Based on the diagnosis presented, it is understood that the focus of actions to expand transportation network infrastructure should be on the following:

- Promoting the expansion of long-distance transportation networks (backhaul) to the 683 municipalities lacking this infrastructure and which do not yet have established obligations.
- Promoting the expansion of long-distance (backhaul) transportation networks to the more than 32,458 non-municipal headquarters locations that do not yet have this infrastructure
- Prioritizing service provision with new backhaul networks in the North and Northeast regions of Brazil;
- Promoting the expansion of backhaul networks to rural areas that require this type of technology.

683 municipalities without fiber optics and no obligation to provide service

Rural Areas

32,458 locations without fiber optics and no obligation to provide service

North and Northeast Regions

Mobile Coverage

Regarding the network infrastructure to support Personal Mobile Service – SMP, the Brazilian service provision scenario is marked by the presence of 3 (three) large economic groups, which concentrate 94.9% of service accesses: Telefônica, Claro and TIM (Anatel data panel).

All districts that are the headquarters of Brazilian municipalities are covered by mobile networks, with fourth-generation (4G) technology being predominant, already allowing good broadband access. This situation stems from coverage commitments imposed in the Auction processes for radio frequency usage rights, under the coordination of Anatel.

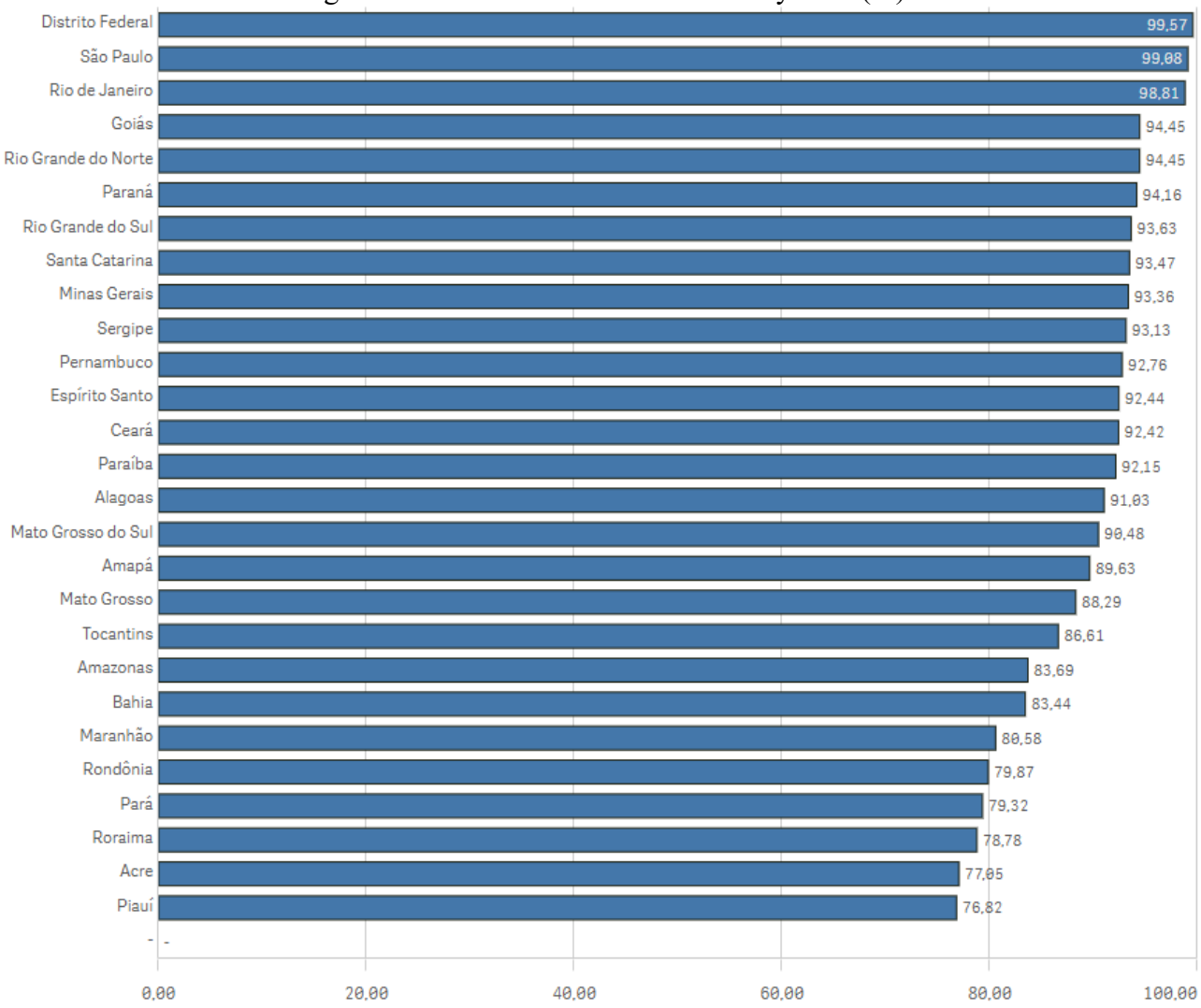
Considering the dominant technology (4G), we have a scenario of mass mobile service, reaching 99.45% of residents in urban areas and 44.72% of residents in rural areas.

Figure 12: 4G technology penetration

Source: Infrastructure Panel. Anatel (June/2025)

Analyzing this penetration by state, we find that 16 states have percentages lower than the national average, with 7 in the North region, 6 in the Northeast region, 2 in the Central-West region, and 1 in the Southeast region:

Figure 13: Residents covered with 4G by state (%)



Source: Infrastructure Panel. Anatel (June/2025)

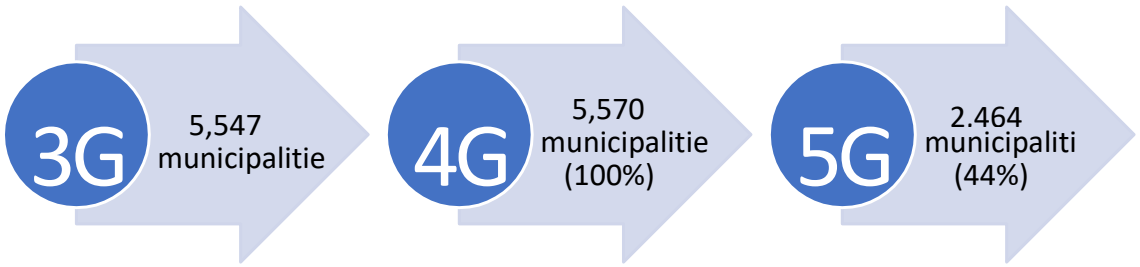
Technologies

Regarding the presence of mobile technologies in Brazilian municipalities, as previously reported, 4G technology predominates, reaching 92.56% of residents and present in all 5,570 municipalities in Brazil (06/2025) [13].

However, the country already has 5G technology present in 2,464 municipalities, serving 78.39% of Brazilians.

For legacy 2G and 3G technologies, the Anatel panel indicates their presence in 5,529 and 5,547 municipalities, with coverage of 90.58% and 92.65%, respectively.

[13] https://informacoes.anatel.gov.br/paineis/infraestrutura/cobertura-movel



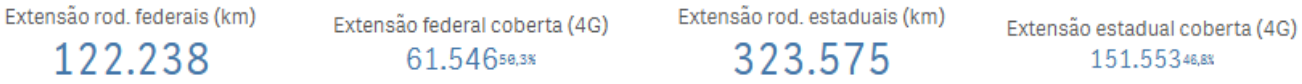
Regarding 5G, the expansion has been quite rapid, exceeding the schedule established by the Auction[14]. The initial plan was to serve municipalities with more than 500,000 inhabitants by July 2025; however, by August 2023, municipalities with more than 30,000 inhabitants were already being served by this technology. With the established obligations, all municipal headquarters will be served by this technology by 2029.

Highways

Due to Brazil's vast territory and extensive road network, highways play a fundamental role in economic and social development.

In the case of the federal highway network, there are a total of 122,238 km, including all types of pavement (according to data from the National Department of Transport Infrastructure - DNIT), with 61,546 km covered by 4G technology[15]. In addition, 151,553 km of the 323,575 km of state highways are also covered with the technology:

Figure 14: Extent of 4G Coverage on Federal and State Highways



Source: Infrastructure Data Panel. Anatel (2025).

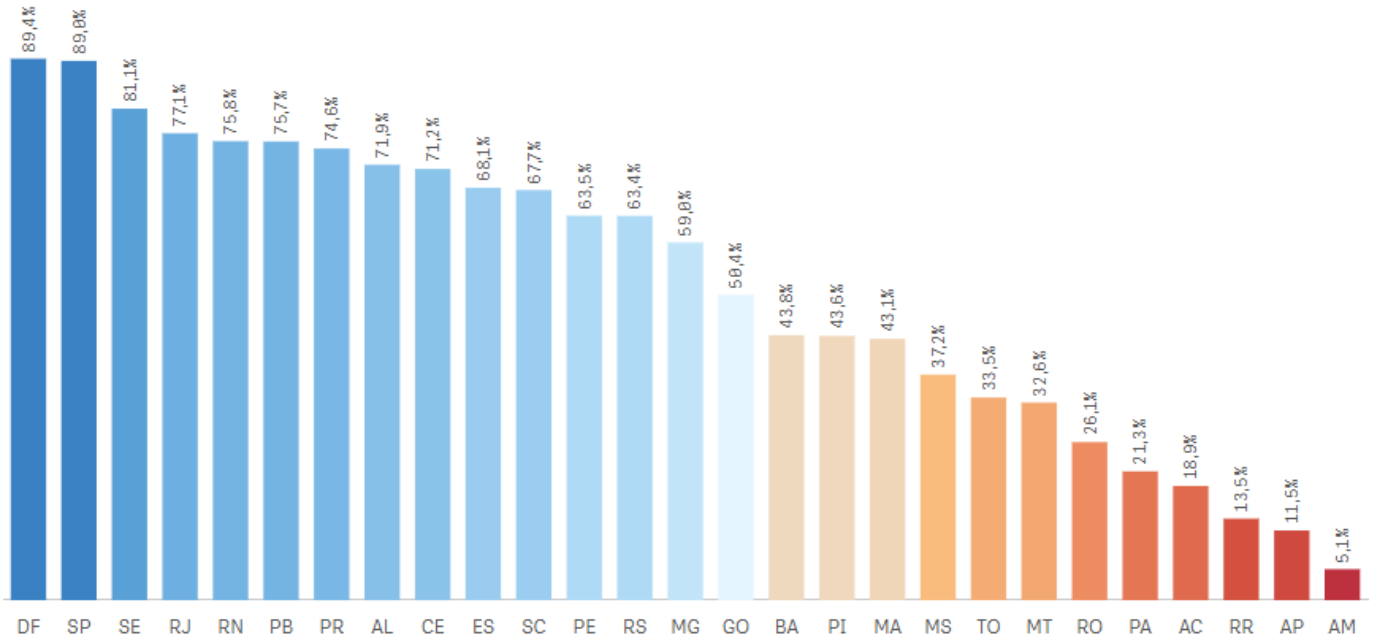
Also, 17,029 km of federal highways and 35,034 km of state highways are covered by 5G, due to the rapid expansion of this technology.

The analysis of regional characteristics show that there is a large disparity in the coverage of federal highways among the states.

[14] https://www.gov.br/anatel/pt-br/regulado/universalizacao/compromissos-do-leilao-do-5g

[15] Starting in September 2024, the coverage attenuation thresholds in 4G and 5G technology predictions were adjusted from -110 dBm to -90 dBm. This change aims to make the estimates more accurate, providing a more realistic representation of the mobile phone signal for these technologies.

Figure 15: Extent of 4G coverage on federal highways by state



Source: Infrastructure Data Panel. Anatel (June/2025).

The 12 states with coverage percentages lower than 50% are in the North (7), Northeast (3) and Central-West (2) regions.

Federal and state highways are important routes for transporting the country's economic output, making their coverage with broadband technology of fundamental importance.

It should be noted that the gap in 4G mobile network coverage on federal highways was the subject of an investment commitment during the 5G Auction, at which time Winity II Telecom LTDA was the winning bidder. However, the provider relinquished its telecommunications service authorization and, consequently, the associated radio frequency usage authorization, thus terminating the commitment made at the time.

Through Ordinance No. 18,902, of July 10, 2025, the Ministry of Communications established the guidelines for the next Auction process for the 700 MHz radio frequency bands, with provision for 4G or higher technology coverage, in the underserved sections of the federal highways BR-101, BR-116, BR-135, BR-163, BR-242 and BR-364.

Locations (IBGE and non-IBGE)

In the 2022 population census, IBGE conducted a population survey of various types of locations, including cities, districts, towns, rural agglomerations, villages, hamlets, settlements, settlement projects, indigenous villages, and isolated urban areas (IUA)[16].

[16] https://geoftp.ibge.gov.br/organizacao_do_territorio/estrutura_territorial/localidades/cadastro_localidades_selecionadas.pdf

To properly map mobile coverage in the Brazilian population, Anatel chose to use the IBGE's database of locations in order to estimate the population covered by mobile service, by type of technology.

Considering the criterion of minimum coverage of 95% of the municipal territory, many locations are still not covered. However, the obligations established in various regulatory instruments of the Agency will contribute to significantly altering this scenario, although there are still many challenges.

As a result of the 5G Auction, for example, by 2030 there will be 7,430 locations served with 4G or superior technology and 1,700 locations with 5G technology.

Figure 16: Overview of 4G coverage in different locations

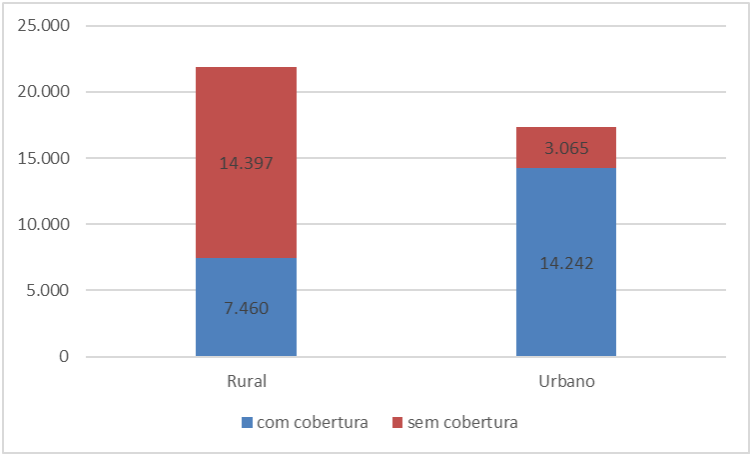
Source: Infrastructure Data Panel. Anatel (June/2025).

It is worth noting that the Agency mapped 19,238 locations that are not included in the IBGE's (2022) census sector mapping and that were not included in the Auction requirements. These locations were identified through: surveys conducted by fixed-line telephone companies as part of the General Universalization Goals Plan – PGMU; requests for telecommunications services to these locations; and surveys of quilombola communities carried out by the Palmares Foundation and Incra.

Urban vs. Rural

Considering the classification of census tracts by the IBGE Census of 2022, there are 21,857 rural locations and 17,307 urban locations:

Figure 17: Overview of 4G coverage in urban vs. rural areas.



Source: Infrastructure Data Panel. Anatel (June/2025).

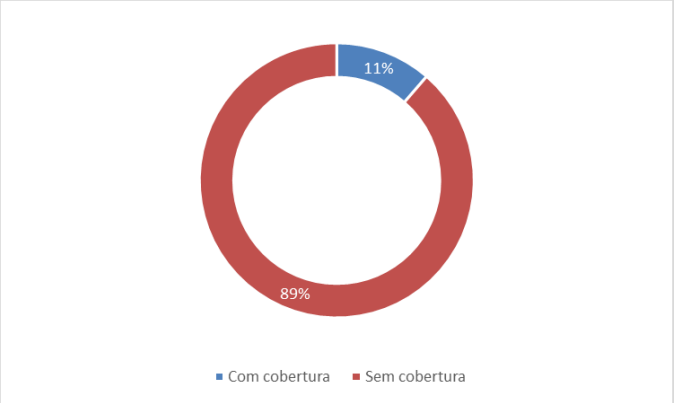
The numbers reveal the discrepancy in coverage between urban and rural areas, with a large gap in rural areas, where 66% of locations are not covered, while in urban areas this percentage

is 18%. In general terms, 44.72% of residents and 13.30% of the rural area in the country have 4G mobile coverage (53.71% of residents and 16.93% of the rural area with any technology).

Indigenous Villages

Considering the 2,845 locations identified as indigenous villages by the 2022 IBGE Census, only 11% have 4G coverage, if we consider the minimum percentage of 95% of the locality's area to have coverage:

Figure 18: Coverage of indigenous villages (4G)



Source: Infrastructure Data Panel. Anatel (June/2025).

It is worth highlighting that 2,289 locations, equivalent to 80% of the indigenous villages mapped by IBGE, show no 4G mobile coverage signal, according to the Agency's coverage simulations. These results demonstrate the need to improve the mapping and service of these locations classified as indigenous villages by IBGE, which represent 231,156 residents.

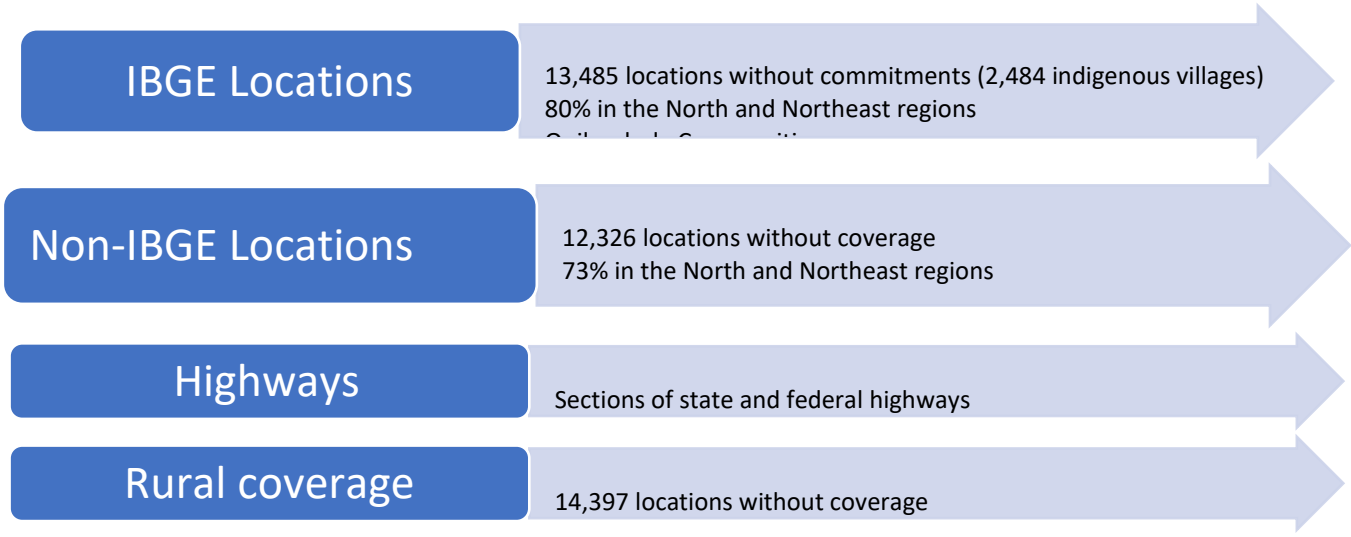
The lack of 4G mobile coverage in indigenous villages highlights the urgency of initiatives aimed at the digital inclusion of these communities. Improving mapping and prioritizing investments in telecommunications infrastructure are essential steps to ensure that all areas, especially the most vulnerable, have access to connectivity, promoting social and economic development.

Gaps

Despite the progress made, significant gaps in 4G mobile coverage still exist in several regions, especially in indigenous, rural, and remote areas. These gaps reflect structural and investment challenges that hinder the universalization of connectivity. The persistence of these areas without coverage highlights the need for more effective and targeted strategies, including strict compliance with regulatory obligations and collaboration with different levels of government to promote broad and equitable digital inclusion.

With the obligations to provide 4G or higher SMP coverage in the 5G Auction, TACs and Obligations to Do[17], we will still have the following gaps:

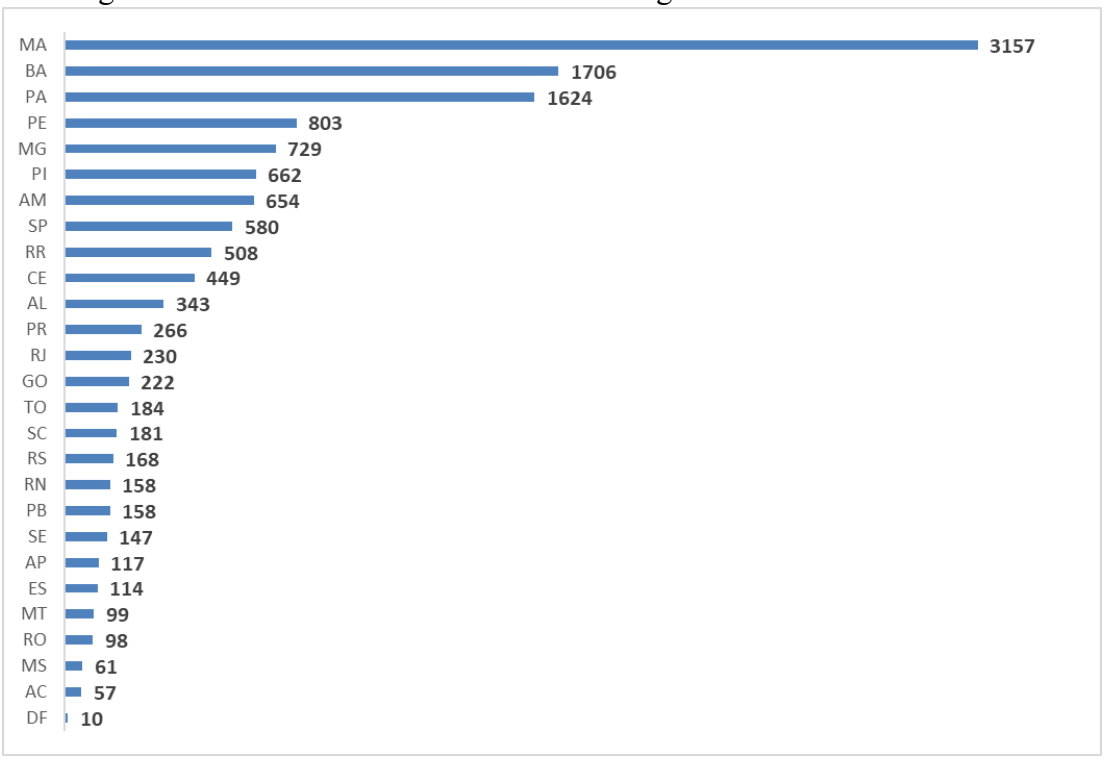
[17] https://informacoes.anatel.gov.br/paineis/acompanhamento-e-controle/compromissos-de-investimento



These gaps identified in the present diagnosis are concentrated mainly in the North and Northeast regions, with 80% of all IBGE locations lacking coverage and commitment (a total of 13,485), with 56% in the Northeast region alone (Figure 19).

Also noteworthy are the states of Maranhão, Bahia, and Pará, with the highest numbers of unserved locations among the federative units (23%, 13%, and 12%, respectively).

Figure 19: IBGE locations without 4G coverage and without commitment



Source: Infrastructure Data Panel. Anatel (June/2025).

Public Points of Interest

Public points of interest are those of interest to the public administration in developing policies to expand access to high-speed internet, such as public schools, health units, police stations, environmental conservation units, border posts, among many others.

In this chapter, we will present points of public interest related to some sectors of the economy in which the Agency has interacted with the responsible State bodies.

However, both on Anatel's website and in future updates to the PERT, new mappings of public points of interest should be presented in order to support public connectivity policies. This presents an opportunity for Anatel to strengthen ties with various Ministries in order to gather information about connectivity needs in different sectoral verticals.

Diagnosis of Broadband Connectivity in Schools

The diagnosis of broadband connectivity in Brazilian public schools presents a comprehensive overview of the progress and challenges in the digital inclusion of educational institutions. The survey, based on data from the School Census and other government initiatives, identified 137,914 schools, of which 40% can be considered connected with parameters adequate for pedagogical use in the classroom, while 5.3% face a total lack of connection or even electricity. This gap is more evident in rural areas, where 93% of schools lack any connection.

The data show significant regional differences. Schools in the South and Midwest stand out with 55.41% and 49.89%, respectively, of institutions having adequate parameters for pedagogical use in the classroom. On the other hand, the North presents the greatest challenges, with only 21.58% of schools in this situation, followed by the Northeast, with 40.31%. These disparities reflect the need to prioritize public policies aimed at the most vulnerable regions.

Another relevant point is the impact of school size on connection quality. Smaller schools, with up to 100 students enrolled, face more difficulties, with 6,381 (14.28%) lacking any connection. Medium-sized schools, with 200 to 500 students, have 204 schools (0.5%) without any connection, indicating that digital inclusion policies should consider this variable to ensure greater equity.

Connectivity gaps are even more critical in schools located in remote regions, where geographic and economic factors hinder the deployment of broadband infrastructure. These areas often rely on specific initiatives and government subsidies to enable internet access. Programs like PCI play a key role in reaching these institutions.

The study also reveals that connection quality is directly linked to the adoption of technologies in the school environment. Schools with better infrastructure tend to use the internet more effectively in teaching, amplifying the positive impact on learning. This data reinforces the importance of ensuring not only access, but also the suitability of the connection to pedagogical needs.

Although progress has been made, especially in urban areas, there are still significant gaps that directly affect equity in access to digital education. The Northern region, for example, continues to be the most disadvantaged, both in terms of infrastructure and the quality of service offered. This scenario demands special attention in public policy strategies.

Among the recommendations, the prioritization of smaller schools located in rural areas stands out. These often-neglected institutions play a crucial role in the digital inclusion of the communities in which they are located. Subsidizing high-speed internet connections for these schools is essential to reducing inequalities.

The National Connected Schools Strategy (NCSS) proposes the universalization of quality connectivity in public schools by 2026. This objective requires a joint effort between government, the private sector, and civil society to overcome existing barriers. The implementation of more robust and accessible networks can transform public education in Brazil.

Besides, continuous monitoring of connectivity indicators is necessary to assess the impact of adopted policies and adjust strategies as needed. Monitoring also allows for the identification of new gaps and a rapid response to them, ensuring that no school is left behind in the digital inclusion process.

The data presented in this diagnosis were extracted from various government sources, including the School Census, the Broadband in Schools Program (BBSP), and other initiatives such as the Connected Education Meter and the Connected Northeast program. For complete information, please consult the detailed study on the Connectivity Panel in Public Schools[18].

Turism

Tourism in Brazil, as mapped and described by the Brazilian Tourism Map, represents an essential driving force for the local economy, with significant impacts on job creation, social development, and the promotion of regional culture and identity. Each tourist region, composed of bordering and integrated municipalities, acts cohesively to enhance the tourism offer, stimulating the growth of the sector in their respective territories.

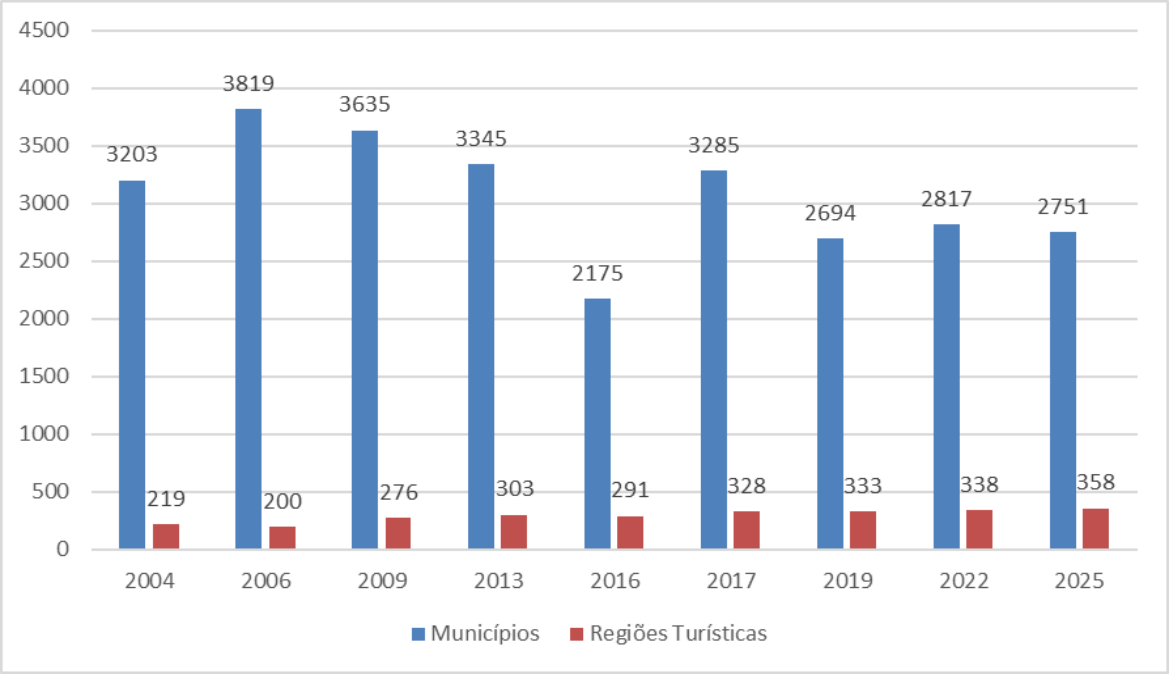
The digital transformation of the tourism sector not only improves the visitor experience but also boosts the competitiveness of Brazilian tourist regions. By integrating advanced technological solutions, such as 5G connectivity, it is possible to promote more efficient destination management, with access to real-time data that supports quick and informed decisions. This advancement allows for more agile communication between service providers and tourists, facilitating the planning and personalization of travel experiences, as well as contributing to the preservation of natural and cultural heritage.

Also, increased connectivity in tourist regions creates opportunities for small businesses and local entrepreneurs, who can use digital tools to attract and interact with visitors more effectively. Connected tourism creates a dynamic ecosystem that encourages regional development, providing economic benefits to communities that traditionally did not have access to the advantages of digitalization. With the right infrastructure, Brazil can explore the full potential of its natural and cultural riches, ensuring that tourism continues to be a driving force for sustainable development.

In light of these considerations, it is crucial that the PERT incorporates an approach that takes into account the needs and peculiarities of regional tourism. Specifically, the deployment of 5G technology is an invaluable opportunity to enhance the tourism potential of the regions. A robust and efficient telecommunications infrastructure is a prerequisite for improving the tourist experience, facilitating the management of tourist destinations, and promoting the sustainable development of tourism.

[18] https://informacoes.anatel.gov.br/paineis/infraestrutura/conectividade-nas-escolas

Figure 20: Map of Brazilian Tourism



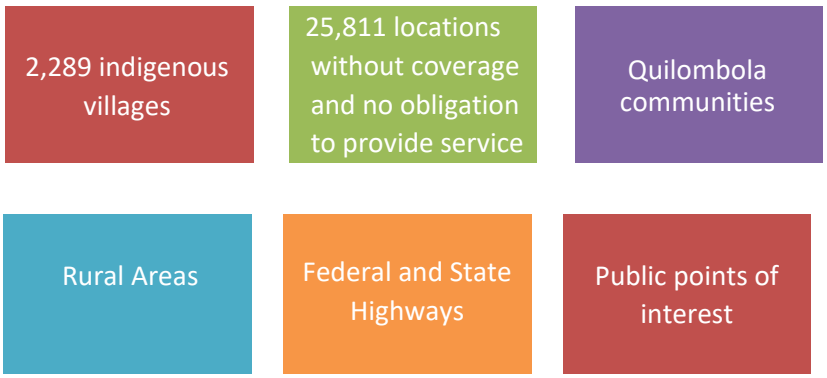
Considering the sampling methodology, which is based on official data and specific criteria such as the composition of municipalities on the Map, categorization of municipalities, and the quality of internet service, among others, it is crucial that investment and deployment decisions for 5G infrastructure prioritize regions with high tourism potential and those considered anchors for national tourism.

Besides, the inclusion of 5G technology in tourist regions will provide leverage to the sector, promoting rapid access to information, improving communication, and expanding the tourism offer. This step is especially relevant in the post-pandemic scenario, where a growing trend towards regional tourism is observed, highlighting the need for a solid and efficient telecommunications infrastructure.

Finally, by aligning the goals and objectives of the PERT with the needs and priorities of the tourism sector, not only is the economy strengthened and regional development promoted, but it is also ensured that Brazil continues to be a leading tourist destination on the global stage.

Challenges

Based on the diagnosis presented, the focus of actions to expand mobile access infrastructure would be:

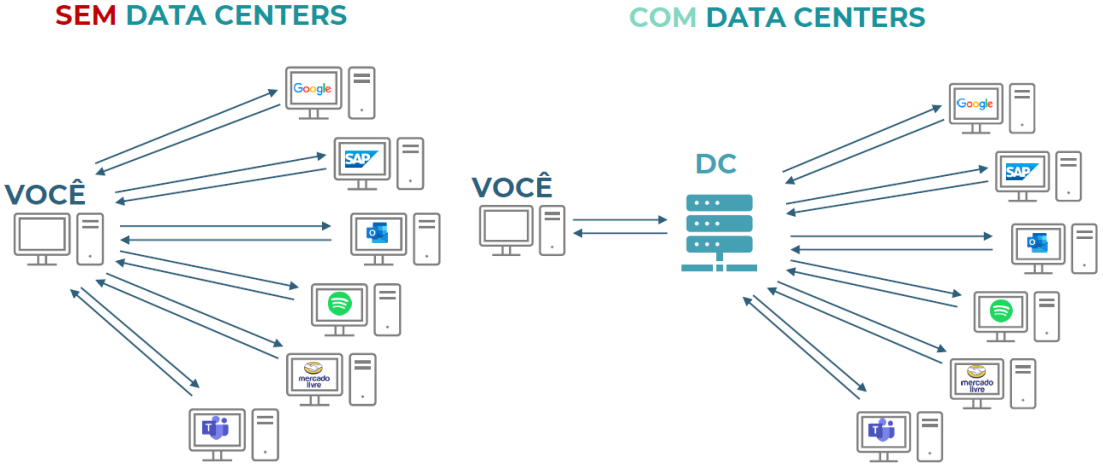


Data Centers

Data centers play a central role in digital transformation, enabling the large-scale storage, processing, and distribution of data. They support emerging technologies such as Artificial Intelligence (AI), Big Data, the Internet of Things (IoT), and mobile networks like 5G. In an increasingly connected world, the presence and evolution of data centers are essential to meet the growing demands of the digital economy.

Figure 21 illustrates how data centers structure user interaction with the digital ecosystem, eliminating capacity barriers and optimizing the use of network infrastructure.

Figure 21: Environment without and with Data Centers



Currently, the global data center industry is responsible for an estimated annual economic impact of US$5.55 trillion, approximately 6% of global GDP[19]. In Brazil, the expansion of data centers

[19] https://www.digitalrealty.dk/resources/articles/qualifying-the-the-value-of-data-centers

represents a strategic opportunity to reduce regional connectivity gaps and foster new digital businesses.

ABIresearch[20] predicted that by the end of 2024 there will be approximately 5,709 public data centers, comprising 5,186 colocation sites and 523 hyperscale sites. The highest concentration of this infrastructure is found in the Asia-Pacific region, followed by Europe and North America. It is expected that by 2030, approximately 8,378 data centers will be in operation.

Figure 22 details the geographic distribution of the main data centers in Brazil. This mapping is important for identifying areas of vulnerability and opportunities for expansion, ensuring that providers can efficiently meet the growing demand.

There is a greater concentration in the Southeast region, although data centers are also present in all regions of Brazil.

Figure 22: Distribution of data centers in Brazilian territory

Source: www.datacentermap.com

Data centers can be classified according to energy consumption and the degree of customization of the facilities:

- On-Premises: Lower energy consumption, located within companies, lower efficiency;

[20] https://www.abiresearch.com/blogs/2024/07/16/data-centers-by-region-size-company/

- Retail: Higher consumption, but distributed among different customers, dedicated building, redundant architecture (N+1);
- Edge: Designed to be closer to users and enables new markets;
- Wholesale/Hyperscale: High energy consumption/density, efficiency from building design, customer-defined customization.

The company Scala Data Centers[21] understands that, due to the increasing applications associated with Artificial Intelligence (AI), the outlook for the Data Center market is one of vigorous growth until 2028 (Figure 23).

It is worth noting that the energy demand in data centers operating AI applications is approximately ten times greater than that of traditional applications (Figure 24).

Figure 23: Growth outlook for the LATAM Data Center market

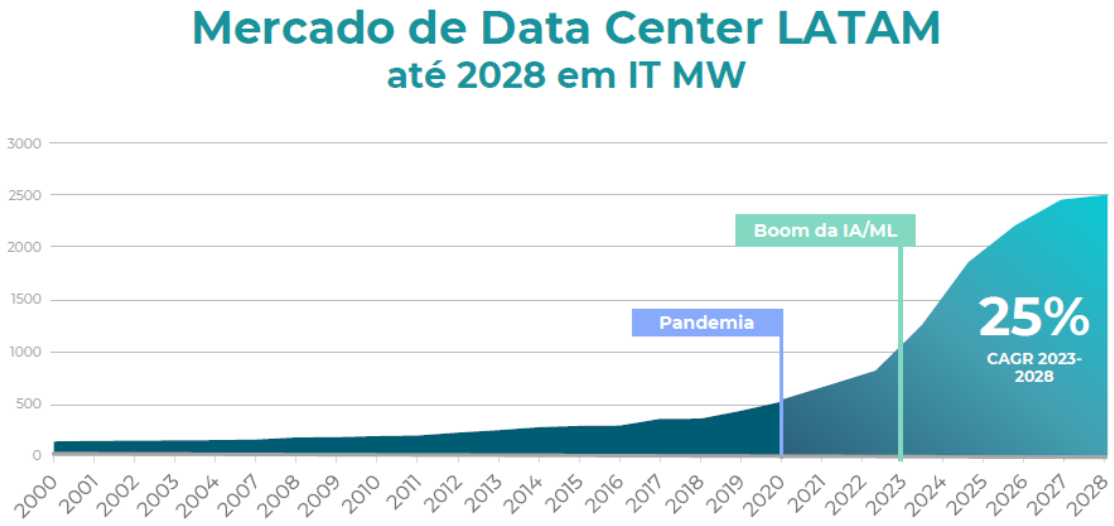
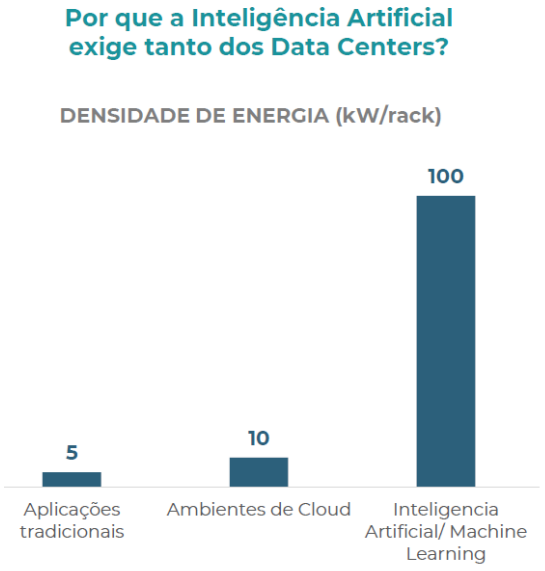


Figure 24: Energy density (kW/rack)



[21] scaladatacenters.com

To support this accelerated growth of digitalization, it is necessary to pay attention to three important pillars:

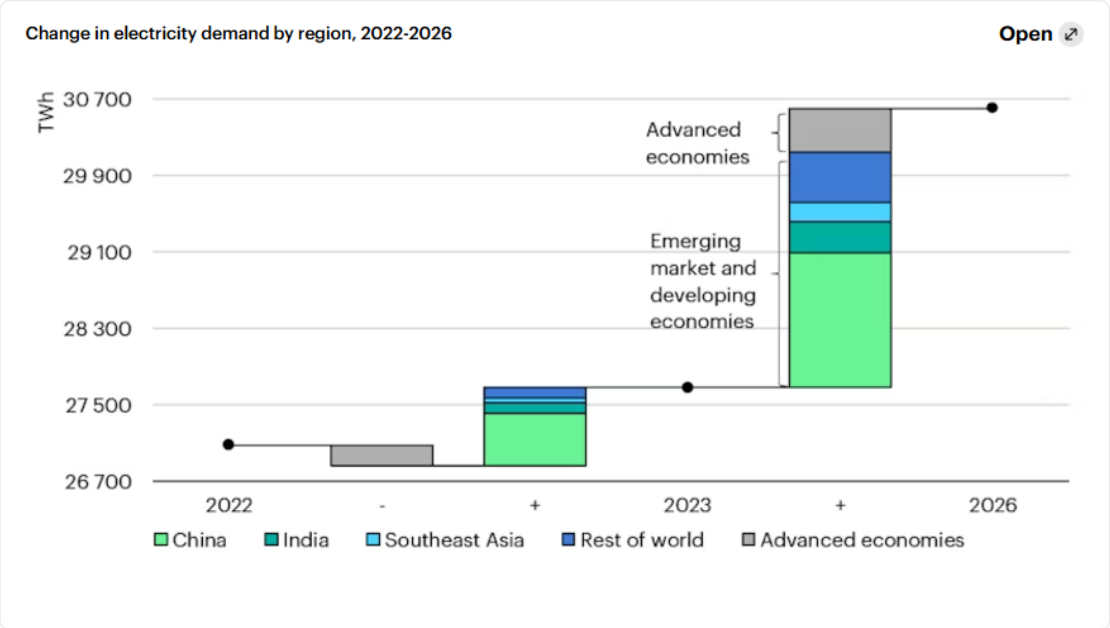
- The availability of energy, preferably renewable;
- The increase in connectivity options;
- The existence of a regulatory environment that favors the generation of new businesses.

Energy Demand and Sustainability

A significant portion of the operating costs (Opex) of data centers is allocated to electricity payments. According to a report by the International Data Corporation (IDC)[22], *electricity is by far the largest ongoing expense for data center operators, accounting for 46% of total corporate spending and 60% for service providers.*

According to the International Energy Agency[23], in its Electricity 2024 report, global energy demand is expected to grow by an average annual rate of 3.4% until 2026. For Data Centers, Artificial Intelligence, and Cryptocurrencies, energy consumption is expected to double by around 2026. Figure 25 below shows the change in energy demand by region of the world between 2022 and 2026.

Figure 25: Demand for Electricity, by Region (2022-2026)



Given the importance of data centers, the following recommendations are presented to enhance the competitiveness and sustainability of this sector in Brazil:

1. Tax and regulatory incentives: Attracting investment in sustainable and efficient facilities.
2. Renewable energy: Encouraging the use of clean energy sources for supply.
3. Robust connectivity: Expanding network infrastructure to support new demands.
4. Interinstitutional collaboration: Promoting partnerships between government, the private sector, and academia.

[22] https://www.idc.com/getdoc.jsp?containerId=prUS52611224

[23] https://www.iea.org/reports/electricity-2024/executive-summary

Besides, to ensure the resilience and operational efficiency of data centers, it is essential to implement advanced monitoring and management solutions, such as the use of artificial intelligence to predict failures and optimize resource consumption. The adoption of redundant architectures, such as N+1 and 2N, combined with the use of liquid cooling technologies and renewable energy storage, can significantly increase energy efficiency and responsiveness to growing demands. These advancements, aligned with regulatory guidelines and global trends, solidify data centers as a strategic pillar of the national critical infrastructure.

This approach will ensure that Brazil positions itself as a leader in the digital transition, with modern, efficient infrastructure aligned with the Sustainable Development Goals (SDGs).

Research

Data from external research adds value to the information already collected by the Agency and allows for a better understanding of the current situation and evolution of telecommunications in the country.

The main findings of the latest ICT Households [24] and PNAD ICT[25] surveys, from the perspective of access to network infrastructure, help to corroborate Anatel's diagnosis:

ICT Households 2024	PNAD ICT 2024
➢ 83% of households have internet access; ➢ 85% of urban households and 74% of rural households have internet access; ➢ Urban-rural gap of 11%; ➢ Lower percentage of households with internet access in the North (81%) and Northeast (81%) regions; ➢ Northern Region: highest percentage of households with internet access only via mobile network (19%); ➢ 29% of households lack internet access in rural areas and 14% in urban areas due to a lack of available infrastructure; ➢ Fiber optic or cable internet in 67% of urban households and 46% of rural households. ➢ Lower presence of fiber optics or cable in the North and Northeast regions (60%).	➢ 93.6% of households have internet access; ➢ 94.7% of urban households and 84.8% of rural households have internet access; • Urban-rural gap of 9.9%; ➢ Lower percentage of households with internet access in the North (92.1%) and Northeast (91.3%) regions; ➢ Northern Region: lowest use of fixed broadband in the country (84.6%); ➢ 12.1% of households lack internet access in rural areas and 0.9% in urban areas due to a lack of available infrastructure; ➢ The highest percentages of rural households without internet access are in the North and Northeast regions (23.8% and 15.2%, respectively).

Despite the fact that the data provided by Anatel and the research indicated above have different periods, granularities, objectives, and calculation methodologies, they can be seen as complementary in the analysis of broadband internet access penetration, since they all corroborate the

[24] https://cetic.br/pesquisa/domicilios/

[25] https://www.ibge.gov.br/estatisticas/sociais/populacao/17270-pnad-continua.html?edicao=44008

diagnosis of a greater connectivity gap in rural areas, which is also more relevant in the Central-West, North, and Northeast regions of the country.

To better understand the connectivity landscape in Brazil, it is essential to analyze both infrastructure data and data on actual access. The ICT Households and PNAD ICT surveys offer a complementary view of how the internet is used in different areas of the country, highlighting not only connection penetration but also challenges related to service quality and stability. This information is crucial for guiding public policies aimed at digital inclusion, especially in the most disadvantaged regions.

Figure 26: ICT Households Survey 2024

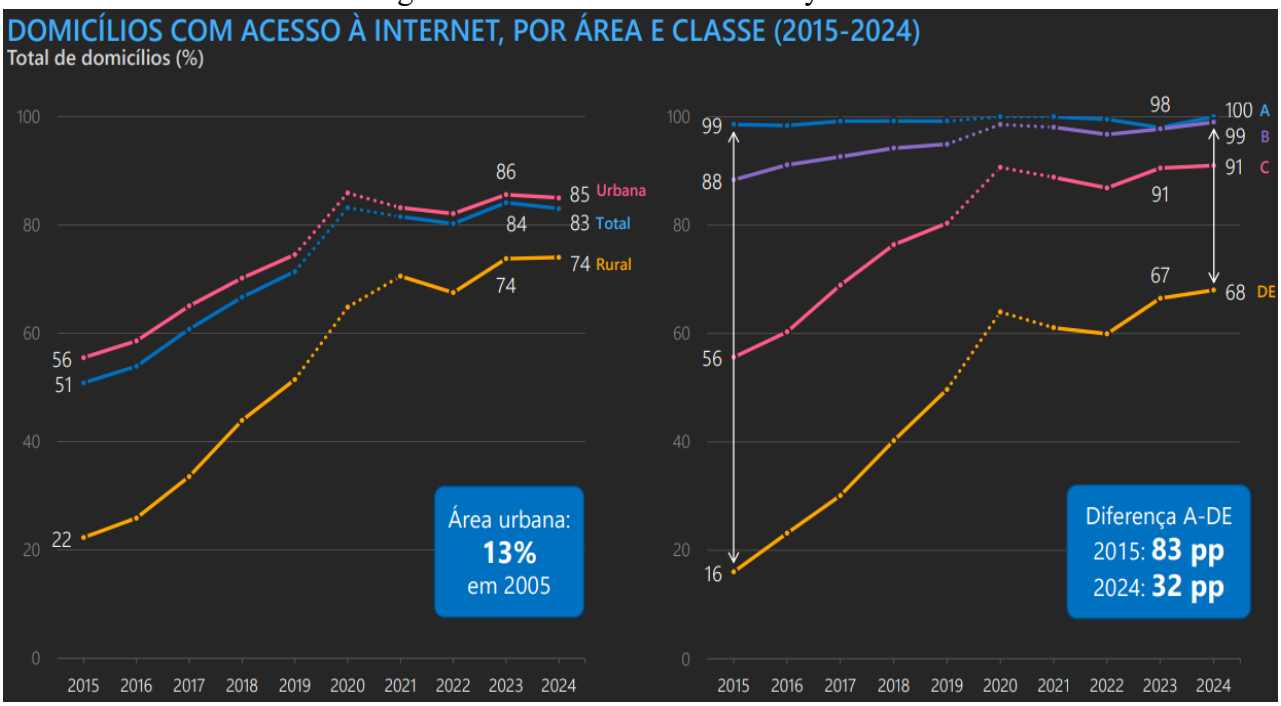
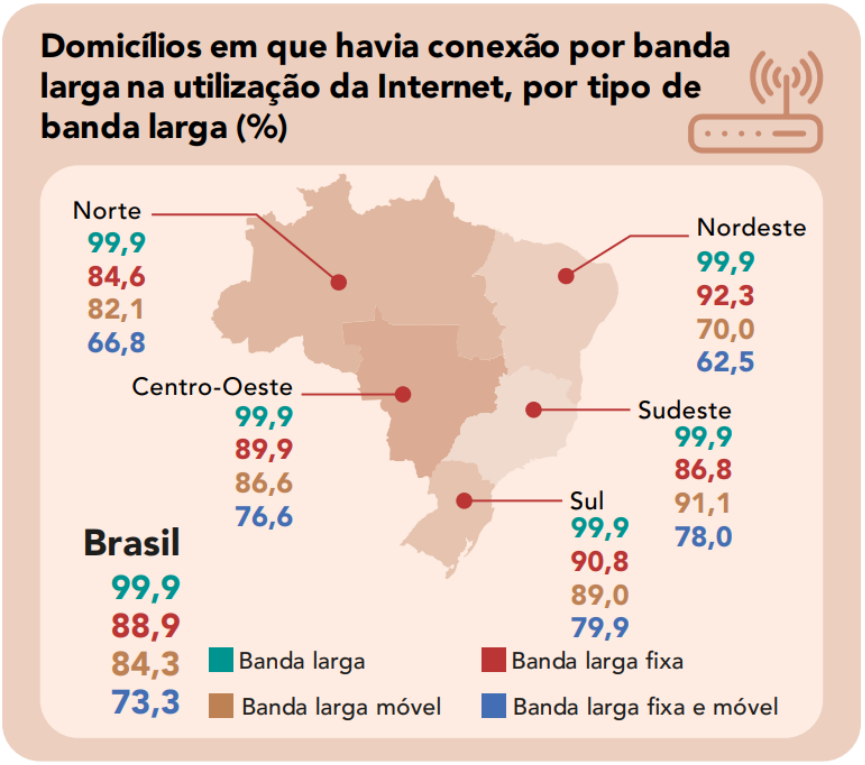


Figure 26 presents the results of the 2024 ICT Households Survey, highlighting the evolution of internet access by area and social class between 2015 and 2024. The graph on the left shows a significant increase in the proportion of households connected to the internet. Urban areas reached 85% coverage in 2024, while rural areas, although improving from 22% in 2015 to 74% in 2024, still have a gap compared to urban coverage. The graph on the right highlights the differences in access by social class, showing that classes A and B have practically achieved universal access (99-100%), while class DE went from 16% in 2015 to 68% in 2024. This evolution reduced the disparity between classes A and DE, from 83 percentage points (pp) in 2015 to 32 pp in 2024, highlighting significant progress, but there are still persistent challenges in terms of digital equity.

Internet connectivity in Brazil varies significantly between regions, reflecting both the available infrastructure and the socioeconomic challenges faced in each location. The following figure, based on the IBGE's 2024 Continuous National Household Sample Survey (Continuous PNAD), illustrates the proportion of households connected by different types of broadband in each region of the country. It highlights how fixed and mobile broadband are distributed regionally, showing the contrasts in access and the most common types of connection in each area.

The advancement of connectivity has generated direct impacts on social inclusion and economic development, but there is still a way to go to ensure that all segments of the population have equal access. Analysis by social class shows that, even with the progress achieved, digital inequality persists, primarily affecting the less privileged classes. Investing in the expansion and improvement of infrastructure is essential to promoting a more connected and inclusive society.

Figure 27: Households with broadband Internet connection

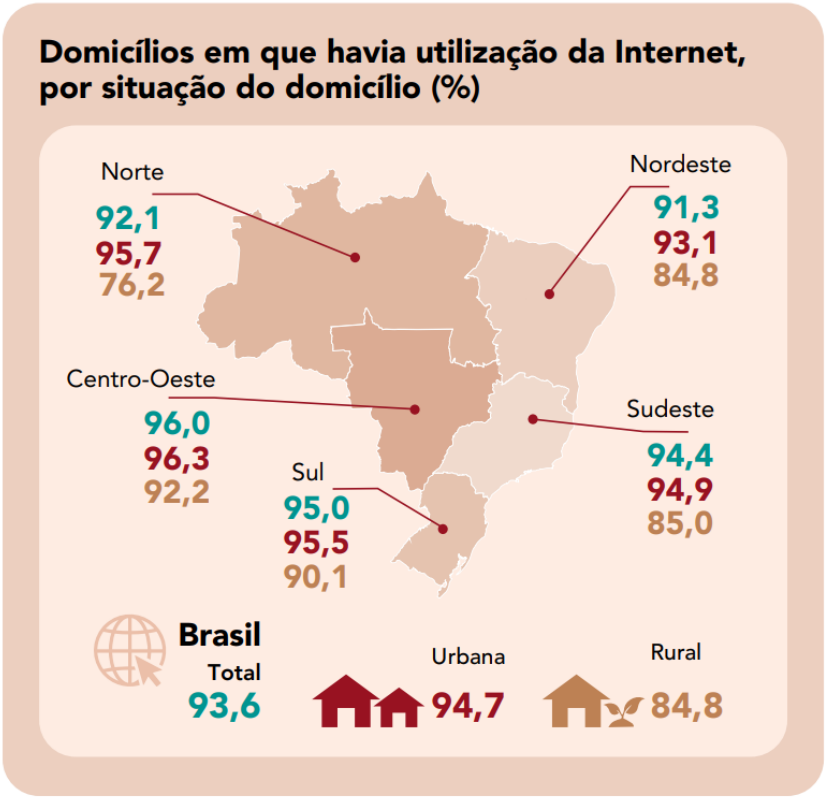


Fonte: IBGE, Diretoria de Pesquisas, Coordenação de Pesquisas por Amostra de Domicílios, Pesquisa Nacional por Amostra de Domicílios Contínua 2024.

Analysis of the figure reveals that, despite high internet penetration throughout Brazil, there are considerable variations in the predominant type of connection in each region. The North and Northeast, for example, show lower availability of fixed and mobile broadband (66.8% and 62.5%, respectively), while the Southeast and South stand out for a more balanced use of fixed and mobile broadband, with fixed broadband representing 86.8% and 90.8% of households, respectively. This disparity reflects structural inequalities in access to telecommunications infrastructure, with more developed regions having greater availability of robust fixed networks, while less favored regions continue to rely more on mobile networks to ensure connectivity.

The analysis of internet connectivity in Brazil reveals disparities not only between regions, but also between urban and rural areas. Differences in the type and extent of access reflect historical and structural challenges that influence social and economic development. The following figure details internet use by household location and region, highlighting these disparities.

Figure 28: Percentage of households where the Internet was used, by household situation, according to Major Regions



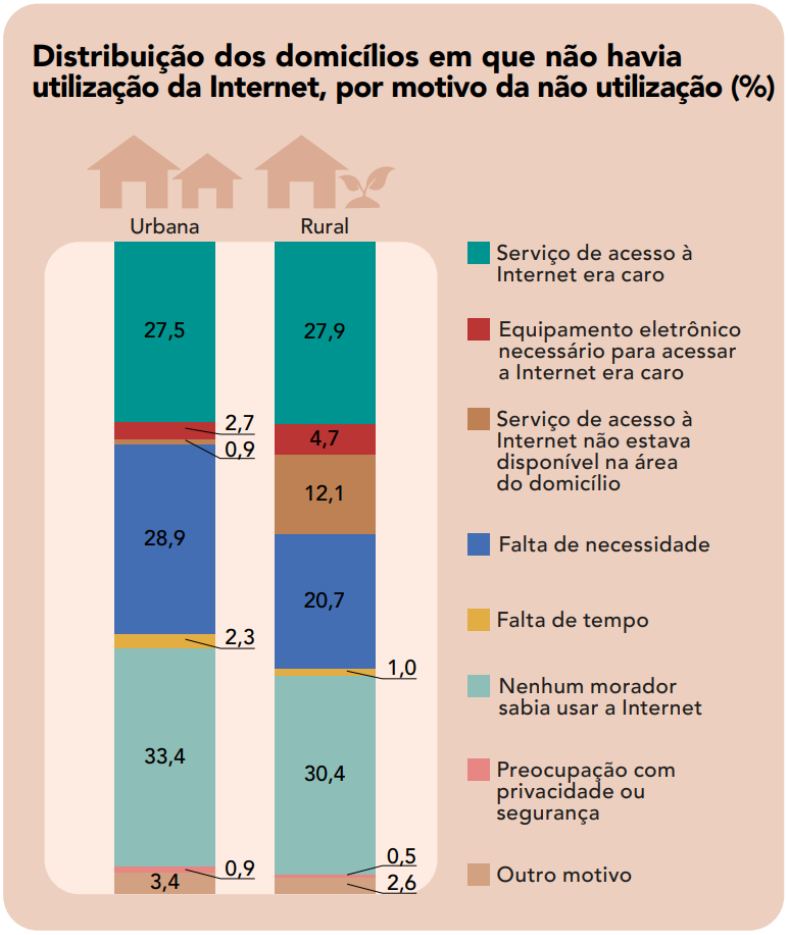
Fonte: IBGE, Diretoria de Pesquisas, Coordenação de Pesquisas por Amostra de Domicílios, Pesquisa Nacional por Amostra de Domicílios Contínua 2024.

The figure shows that, although the national average for internet usage is 93.6%, there is a marked difference between urban (94.7%) and rural (84.8%) areas. The Central-West region has the highest usage rate (96.0%), while the Northeast has the lowest (91.3%), indicating that, despite advances in digital inclusion, regions and rural areas still face significant barriers. These data reinforce the need for public policies focused on expanding connectivity and ensuring more equitable access to the internet, especially for rural and less privileged communities.

The reasons why Brazilian households still do not use the internet vary significantly between urban and rural areas, reflecting differences in access, infrastructure, and perceived need. The following figure details the main reasons that prevent the use of the internet, highlighting both economic factors and limitations in infrastructure and technological knowledge.

Digital inclusion in Brazil still faces significant challenges, especially in rural areas and the North and Northeast regions. While urban areas benefit from improved internet access, there is an urgent need for public policies that guarantee quality infrastructure for all. Overcoming these barriers is crucial for socioeconomic development, allowing all citizens to fully participate in the digital economy.

Figure 29: Percentage of households where there was no internet use, by reason



Fonte: IBGE, Diretoria de Pesquisas, Coordenação de Pesquisas por Amostra de Domicílios, Pesquisa Nacional por Amostra de Domicílios Contínua 2024.

Understanding the reasons why the internet is not used in households is essential for developing more effective digital inclusion strategies. Factors such as high cost, lack of infrastructure, and issues related to the relevance of use are key determinants that influence the behavior of Brazilians, especially in less favored regions. A detailed analysis of these factors helps guide investments and policies aimed at connecting the entire population in a sustainable way.

The last visualization addresses the main reasons why households do not use the Internet, differentiated between urban and rural areas. In urban areas, the main reason is lack of knowledge (33.4%), followed closely by lack of need (28.9%). In contrast, in rural areas, there is lack of availability (12.1%), but lack of knowledge is the main reason (30.4%). These insights show the different barriers faced by Brazilians in urban and rural areas when it comes to internet adoption.

The research corroborates the expansion of mobile telephony, which has been a major driver of increased access. In areas with poor fixed-line network coverage, mobile telephony has been providing connectivity.

The main findings from the latest ICT Households[26] and PNAD ICT[27] surveys, from the perspective of mobile network access, help to corroborate Anatel's diagnosis:

ICT HOUSEHOLDS 2024	PNAD ICT 2024
➢ 14% of households with internet access use the mobile network as their connection; ➢ 82% of internet users access it exclusively via mobile phone in rural areas, compared to 57% in urban areas; ➢ Northern region with 19% of households with primary connection via mobile network	➢ 4.7% of urban households and 24.2% of rural households lack access to mobile phones; ➢ Mobile phone presence is more widespread across major regions, ranging from 95.2% of households in the Northeast region to 98.5% of households in the Central-West region; ➢ In rural areas, consecutive declines were observed in recent years, from 69.4% (2022) to 65.8% (2024)

In addition to the statistics presented, it is crucial to highlight the role of mobile phone operators in mitigating connectivity gaps. With the growth of mobile internet use as the primary form of access, especially in regions with limited infrastructure, the expansion and improvement of these networks are strategic for promoting digital inclusion. Ensuring stable and high-quality access is a challenge that requires a joint effort between the government, the private sector, and civil society.

The figures presented highlight the complexity of the connectivity landscape in Brazil, showing important advances in expanding internet access, but also revealing persistent inequalities. While the expansion of mobile telephony has played a crucial role in locations with poor fixed network coverage, particularly in rural areas and the Northern region, there are still significant barriers, such as high costs, lack of infrastructure, and limitations in technological knowledge. These challenges reinforce the need for political strategies and continuous investments to ensure that meaningful connectivity is a reality for all Brazilians, promoting digital inclusion in all regions and social classes.

[26] https://cetic.br/pesquisa/domicilios/

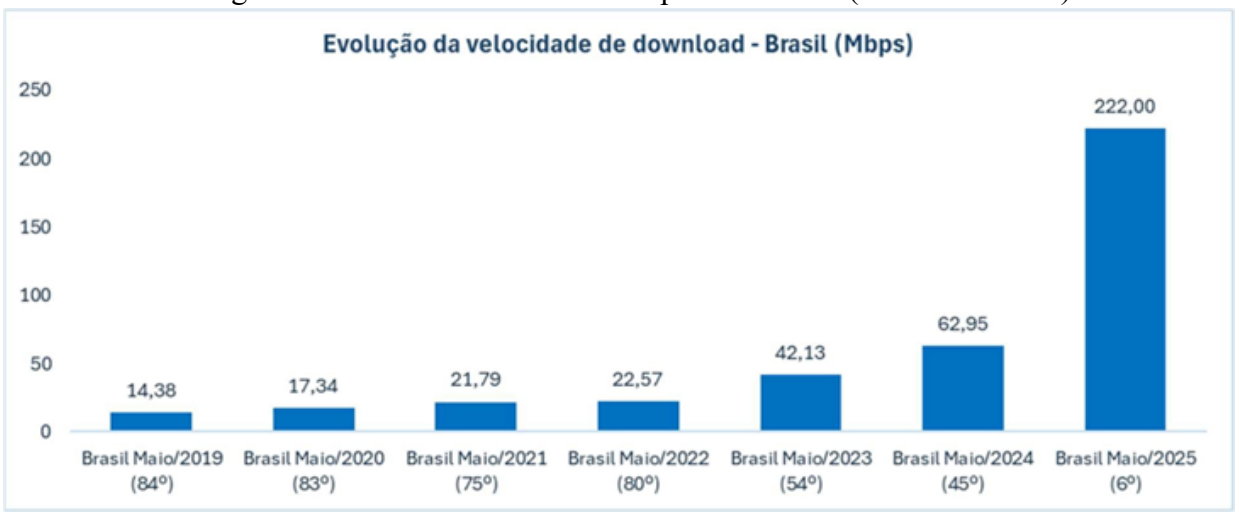
[27] https://www.ibge.gov.br/estatisticas/sociais/populacao/17270-pnad-continua.html?edicao=44008

3. Service Quality and Availability

According to results published by Ookla[28] in May 2025, Brazil recorded a median **mobile network** download speed of 222 Mbps. This result places Brazil 6th in the world ranking for download speed, ahead of countries such as France, Portugal, the United States, Singapore, China, and South Korea.

Evaluating the annual results, Brazil achieved a significant increase in the national median mobile network speed, rising from 17.34 Mbps in May 2020 to 222 Mbps in May 2025, which moved it from 83rd to 6th place in the world ranking. The graph below shows the download results and Brazil's position in the world ranking.

Figure 30: Evolution of download speed in Brazil (mobile network)



In the case of fixed networks, Ookla's data ranks Brazil as the 27th best country in the world, with 201 Mbps, based on data from July 2025.

The Anatel data panel also shows the evolution of contracted speed plans for fixed network access in Brazil.

It is common practice in the fixed broadband internet access market to provide the service with Wi-Fi-enabled routers, most frequently devices capable of using the 2.4 GHz band, and, more recently, dual-band routers, that is, those that operate in the 2.4 GHz and 5 GHz frequency bands.

The 2.4 GHz band has less bandwidth for data traffic (delivering lower speeds) and is more susceptible to interference, given that more devices use it. The 5 GHz band, on the other hand, has greater propagation difficulty and therefore its territorial range is less than that of the 2.4 GHz band.

The figure below illustrates the differences in speed and coverage for the 2.4 and 5 GHz frequency bands:

[28] Data available at www.speedtest.net/global-index

Figure 31: Differences between the speed and coverage of Wi-Fi frequency bands.

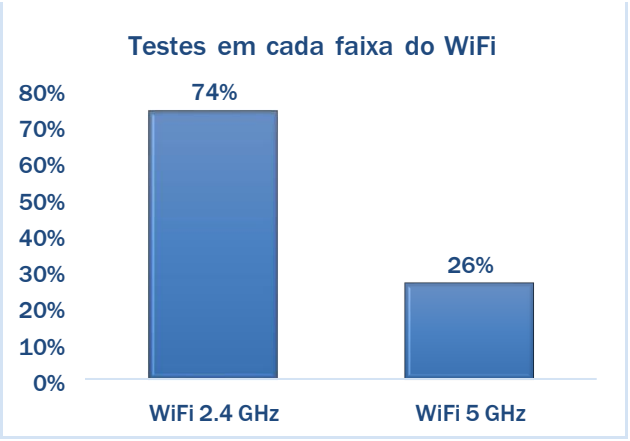
Therefore, the 2.4 GHz network provides consumers with greater coverage, while the 5 GHz network delivers greater capacity.

In this context, it is also worth highlighting the recent arrival of the Wi-Fi 6 standard, or sixth generation of Wi-Fi, which offers advantages over previous standards, such as greater speed, capacity, efficiency, and security.

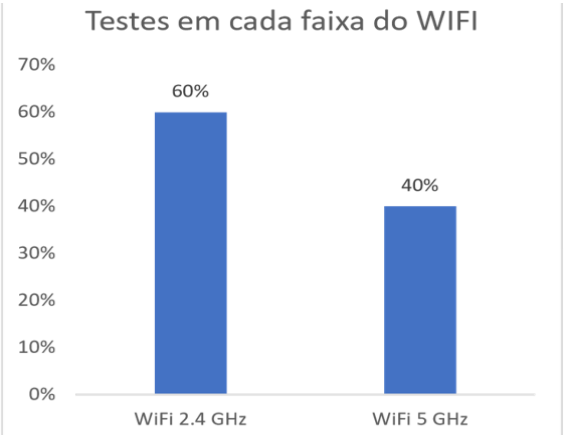
To analyze the use of different frequency bands, it is possible to use the number of tests performed by the official quality assessment tool (resulting from Anatel's Quality Regulation – RQual).

The figure below shows the percentages of tests performed when the user was connected to each Wi-Fi frequency band. This information was obtained using data from the download speed indicator (IND4).

Figure 32: Percentage of tests performed in each Wi-Fi frequency band



2º semestre de 2023



1º semestre de 2025

Although most measurements are still observed in the 2.4 GHz band, there has been a significant reduction in measurements in this band. This is a consequence of the evolution of the device fleet towards terminals compatible with both bands and the increased concern with the quality of the local network. Actions aimed at improving the Wi-Fi user experience have become common,

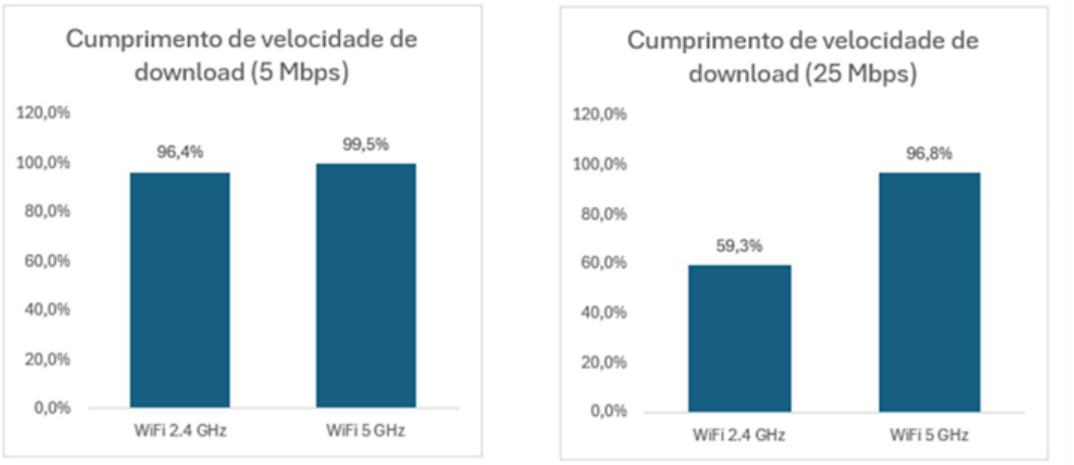
including offering more than one router in the same installation (mesh routers), as well as configuring equipment to try to keep the user on the 5 GHz band for longer.

To analyze performance, it is important to evaluate how the measured quality results behave in the different bands (2.4 and 5 GHz). For this purpose, data from the download speed compliance indicator (IND4) will be used, evaluating exclusively the download direction of the connection.

The IND4 result indicates the percentage of measurements that met the established cutoff value. Two possible scenarios for this indicator were evaluated: meeting the 5 Mbps cutoff value and meeting the 25 Mbps cutoff value, as shown in the figure below.

As expected, it can be observed that, in both cases, the result demonstrates better download speed performance in the 5 GHz band. The performance difference between the two frequency bands is quite pronounced for the higher speed (25 Mbps).

Figure 33: Download speed compliance indicator (IND4) by Wi-Fi frequency band.



It is important to highlight, as pointed out above, that the final access network to the fixed broadband user plays a central role in the overall service experience. Generally, residential fixed broadband access is via Wi-Fi, making this technology one of the relevant elements considered by Anatel when assessing the delivery levels of the contracted speed.

Quality study in subnormal agglomerations and peripheral areas

The adaptations to daily life brought about by the COVID-19 pandemic, whose effects were most felt in 2020 and 2021, highlighted the need for the widespread use of telecommunications resources to overcome the challenges of isolation, especially regarding remote work and distance learning. These challenges proved even greater for people with lower incomes who, for various reasons, were unable to take full advantage of these resources.

Subnormal agglomerations, according to the IBGE, are defined as forms of "irregular occupation of land owned by others – public or private – for housing purposes in urban areas and, in general, characterized by an irregular urban pattern, lack of essential public services and location in areas restricted to occupation".

Based on population and income data from the 2010 census and information on the quality of the Personal Mobile Service network received by the Agency under the Telecommunications

Services Quality Regulation – RQUAL – it was possible to identify service profiles in the largest Brazilian metropolitan areas in order to identify their most vulnerable areas. The complete study is available on the Agency's EIS platform, as well as an interactive map with the classifications performed.

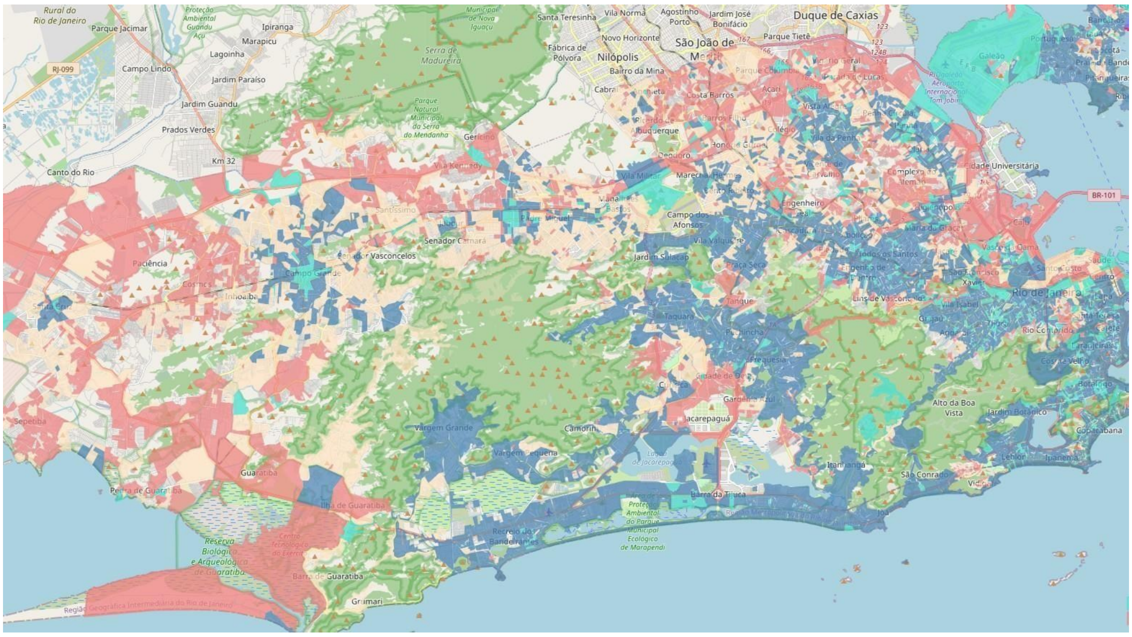
The study consists of a visual presentation of the relationship between mobile data download speeds and residents' income in each census sector of the IBGE (2010 Census). The census tracts were identified based on mobile download speeds (above or below 8.972 Mbps) and average household income (above or below R$ 862.81). The sectors with the highest income were identified in blue and those with the lowest income in red. The study was restricted to the most populous municipalities, as these have more uniform income and urbanization distributions in their census sectors, thus making the comparison between their respective situations more meaningful. However, nothing prevents the findings from being applied to other Brazilian regions in order to quickly identify new potentially vulnerable areas. The Agency has made a dashboard with this information available for public consultation[29].

Inequalities in telecommunications infrastructure are especially visible in the most vulnerable urban areas. These regions, often characterized by a concentration of low-income people, face challenges related to quality connectivity. Digital inclusion in these areas not only promotes social equity, but also offers opportunities to improve education, health, and safety, as well as fostering local economic development. Anatel has been working to identify these areas in order to direct public policies more effectively.

The following map considers the city of Rio de Janeiro, using darker blue to represent areas with higher income and faster internet access, and darker red to represent areas with lower income and slower download speeds, highlighting areas with greater vulnerability in terms of mobile service:

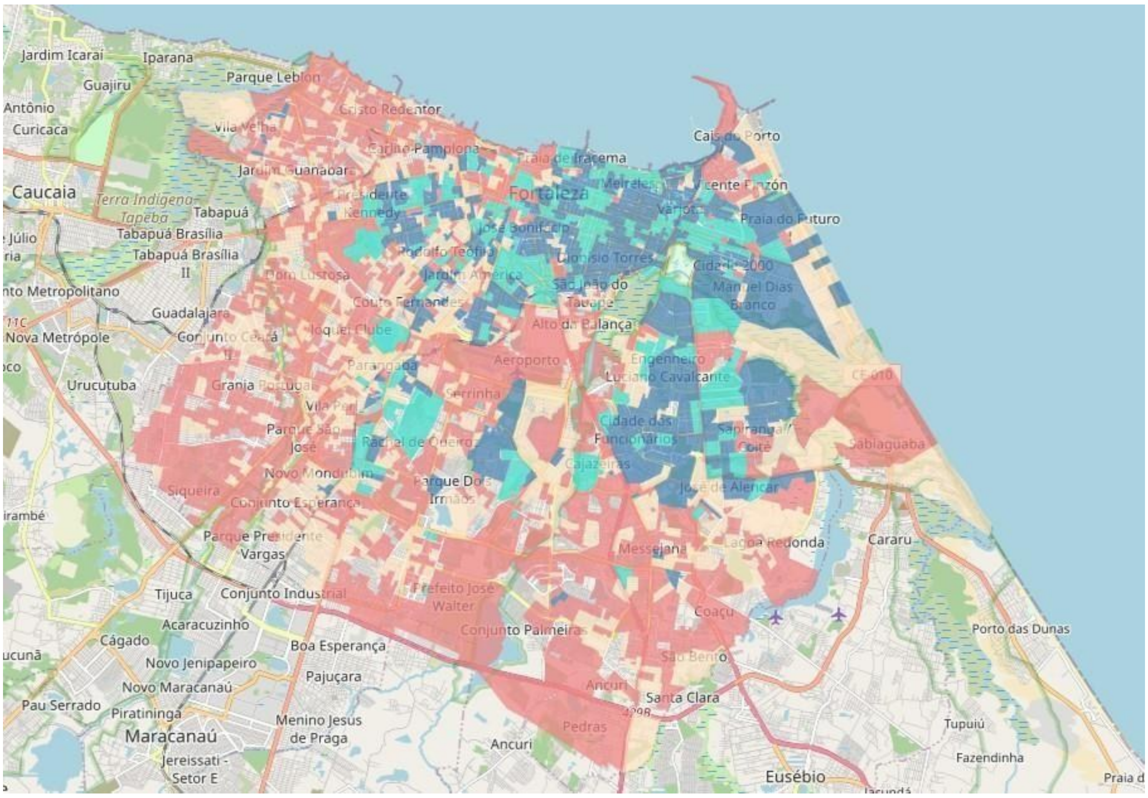
[29] **https://informacoes.anatel.gov.br/paineis/infraestrutura/servico-movel-renda-velocidade**

Figure 34: Speed/Income in Rio de Janeiro



For comparison, the map below shows the situation in the city of Fortaleza, using the same color scheme:

Figure 35: Speed/Income in Fortaleza



Considering the population information from the 2010 Census, 11,175,750 (eleven million, one hundred and seventy-five thousand, seven hundred and fifty) people reside in areas with lower incomes and lower mobile service download rates in the municipalities evaluated in this study, distributed as shown in the following table:

Municipality	FU	Habitants	Number of underserved sectors
MANAUS	AM	949,693	1,174
SALVADOR	BA	764,618	917
FORTALEZA	CE	909,791	1,054
BRASÍLIA	DF	396,027	582
GOIÂNIA	GO	290,641	333
BELO HORIZONTE	MG	528,538	755
BELÉM	PA	526,984	460
RECIFE	PE	520,367	585
CURITIBA	PR	191,580	233
RIO DE JANEIRO	RJ	2,037,417	2,894
PORTO ALEGRE	RS	127,316	174
CAMPINAS	SP	219,373	301
GUARULHOS	SP	470,728	601
SÃO PAULO	SP	3,242,677	4,439
TOTAL		11,175,750	14,502

The municipalities listed in the table stand out for their combination of high population density and digital vulnerability, with download speeds below the national average. This reality reinforces the need for initiatives that prioritize infrastructure improvements in these locations. Implementing public policies that consider these variables can significantly contribute to digital inclusion and the sustainable development of the most affected urban areas.

The study's findings show the need to expand mobile telecommunications infrastructure in the regions identified as having low download speeds, supporting with specific public policies those areas where the lowest-income and therefore most vulnerable population lives.

4. Affordability and Access Costs

Percentage of per capita income (by income bracket)

This chapter addresses the evolution of the national average monthly price of fixed broadband (SCM) and mobile broadband (SMP) services as a proportion of Brazil's average monthly GDP per capita from 2020 to 2025, considering the main attributes of these services – namely, the minimum download speed and the main data allowance, respectively – classified in this document based on the OECD Baskets defined in OECD bundled communication price baskets (2020)[30], as well as explaining the procedures adopted.

National average monthly price of services

The national average monthly price, hereinafter referred to as the average price, was obtained from the databases of the Anatel Comparator application and the Anatel Search for Offers platform, considering the average of the different prices without discount for each of the services, according to the methodology defined by the ITU[31]. Average prices were calculated considering the classifications of the main attributes of fixed broadband (SCM) and mobile broadband (SMP) services – namely, the nominal download speed (download speed stated in each offer) and the main data allowance, respectively, according to the OECD Data Baskets (2020). The following tables present the information from the OECD Data Baskets (2020):

Table 3 – OECD Baskets (2020) for broadband (SCM)

OECD Basket	Minimum download speed (in Mbps)
1	Equal to or greater than 2 and less than 25
2	Equal to or greater than 25 and less than 100
3	Equal to or greater than 100 and less than 250
4	Equal to or greater than 250 and less than 600
5	Equal to or greater than 600 and less than 1,000
6	Equal to or greater than 1,000

Table 4 - OECD Baskets (2020) for mobile telephony (SMP)

OECD Basket	Data allowance (in GB)
19	Less than 1
20	Equal to or greater than 1 and less than 5
21	Equal to or greater than 5 and less than 10

[30] https://www.oecd-ilibrary.org/docserver/64e4c18a-en.pdf?expires=1698326523&id=id&accname=guest&checksum=3FF1A99F060B1C41BC9FF2699698B89

[31] https://www.itu.int/en/ITU-D/Statistics/Documents/ICT_Prices/ICT%20Price%20Basket%20rules_E.pdf

22	Equal to or greater than 10 and less than 20
23	Equal to or greater than 20 and less than 20
24	Equal to or greater than 30

Offers published on the Anatel Search for Offers platform up to August 5, 2025, were used, containing data on telecommunications service offers from 2024 and 2025. Data on offers from 2020 to 2023 were obtained from the older Anatel Comparador application.

Regarding fixed broadband, as previously mentioned, the nominal download speed was used, according to the methodology defined by the ITU[32].

This study maintained the criterion of using only the main data allowance values for mobile broadband (SMP), disregarding the values of special data allowances in the offers, due to their specific use in the applications and services included by the provider in the offer.

In the mobile broadband (SMP) category, offers were used in the Postpaid, Control, and Prepaid payment modalities. In the Prepaid modality, offers with a data allowance validity period exceeding 28 (twenty-eight) days were used. This change ended up causing an increase in the average price for data plans smaller than 1 GB, since prepaid offers with a validity of less than 1 (one) month of service use were excluded.

The following tables present the national average monthly price per service, year, and OECD basket:

Table 5 – Average price of fixed broadband

OECD Basket	Minimum download speed (in Mbps)	2020	2021	2022	2023	2024	2025
1	Equal to or greater than 2 and less than 25	100.97	91.09	77.97	-	-	80.95
2	Equal to or greater than 25 and less than 100	122.45	126.98	101.20	95.40	108.90	104.70
3	Equal to or greater than 100 and less than 250	145.05	143.36	131.65	114.90	101.86	259.67
4	Equal to or greater than 250 and less than 600	220.64	189.32	129.56	140.63	135.29	119.04
5	Equal to or greater than 600 and less than 1,000	-	288.99	207.61	198.49	163.94	133.50
6	Equal to or greater than 1,000	-	229.00	285.53	307.73	307.45	259.88

Table 6 – Average price of mobile broadband

OECD Basket	Data allowance (in GB)	2020	2021	2022	2023	2024	2025
19	Less than 1	63.99	58.43	49.57	46.20	-	38.40
20	Equal to or greater than 1 and less than 5	52.05	48.25	42.36	30.37	33.05	55.95
21	Equal to or greater than 5 and less than 10	78.34	62.13	59.23	49.37	50.46	62.79
22	Equal to or greater than 10 and less than 20	140.85	81.39	76.66	70.14	69.57	79.09
23	Equal to or greater than 20 and less than 30	134.05	125.61	116.51	115.58	145.39	107.59

[32] https://www.itu.int/en/ITU-D/Statistics/Documents/ICT_Prices/ICT%20Price%20Basket%20rules_E.pdf

24	Equal to or greater than 30	373.21	320.76	311.44	287.76	332.24	325.00

Monthly GDP per capita

Regarding monthly GDP per capita, the GDP per capita at current prices for the years 2020 to 2024, obtained from IPEA, was used[33]. For the year 2025, the GDP of 2024 was used, multiplied by the estimated growth for the year 2025, of 2.18%.

Average monthly GDP per capita is simply the GDP per capita divided by the number of months in the year. The following table summarizes the GDP per capita data:

Table 7 – GDP per capita in R$

Description	2020	2021	2022	2023	2024	2025
GDP per Capita	37,290.00	43.670.00	48,830.00	53,640.00	57,330.00	58,579.79
GDP per capita/month	3,107.50	3.639.17	4,069.17	4,470.00	4,777.50	4,881.65

Benchmark Average Price/GDP per capita

To define the benchmark for the Average Price/GDP per capita ratio, we used the proposals contained in the Achieving the 2025 Advocacy Targets[34] of the Broadband Commission for Sustainable Development of the ITU and in the ITU ICT Price Baskets 2024[35]

According to the document, to make broadband more accessible to the population of low- and middle-income countries, the monthly price of the service should be equivalent to a maximum of 2% of GDP per capita by the year 2025.

> *By 2025, entry-level broadband services should be made affordable in low- and middle-income countries (LMICs) at less than 2% of monthly Gross National Income (GNI) per capita*

To define what constitutes a basic broadband service plan, the parameters established by the ICT price data collection methodology were used. For mobile broadband, the document stipulates that the basic plan must include a monthly data allowance of 2 GB, with a minimum speed of 256 kbit/s and 3G technology or higher:

> *The data-only mobile broadband basket is based on a monthly data usage of a minimum of 2 GB. For plans that limit the monthly amount of data transferred by including data volume caps below 2 GB, the cost for the additional data (Megabytes) is added to the basket. The minimum speed of a broadband connection is 256 kbit/s, relying on 3G technologies or above. The data-only mobile broadband basket is chosen without regard to the plan's modality, while at the same time, early termination fees for post-paid plans with annual or longer commitment periods are also taken into consideration.*

[33] Available at: http://www.ipeadata.gov.br/ExibeSerie.aspx?serid=38375

[34] Available at: https://www.broadbandcommission.org/advocacy-targets/

[35] Available at: https://www.itu.int/en/ITU-D/Statistics/Pages/ICTprices/default.aspx

For access to fixed broadband, the ICT price data collection methodology defines that the basic offer must include a data usage allowance of at least 5 GB and a minimum connection speed of 256 kbit/s.

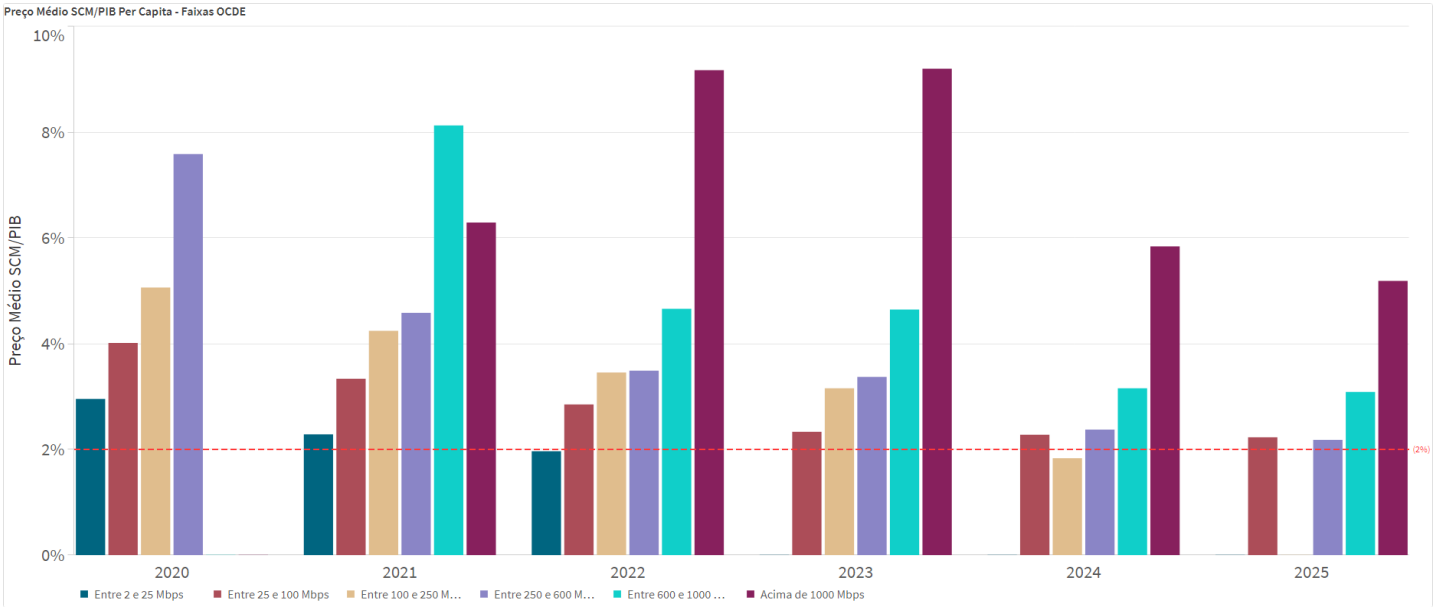
> *The fixed broadband basket refers to the price of a monthly subscription to an entry-level fixed broadband plan. For comparability reasons, the fixed-broadband basket is based on a monthly data usage of a minimum of 5 GB. For plans that limit the monthly amount of data transferred by including data volume caps below 5 GB, the cost for the additional bytes is added to the basket. The minimum speed of a broadband connection is 256 kbit/s.*

Evolution of Price/GDP per capita (monthly average) – 2020/2025

a) Broadband (SCM)

The results found for the SCM are shown in the figure below, where the trend of decreasing relative prices is maintained in almost all speed ranges, as already verified in the PERT Plan – Post CP (EIS No. 13064945). It is important to highlight that in the year 2025, for the speed ranges of 2 to 25 Mbps and 100 to 250 Mbps, Anatel Search for Offers did not receive any registered offers from providers until 2022. Regarding the 2 to 25 Mbps range, this situation began in 2023 and continued into 2024 and 2025. This trend may have resulted from the increased capacity of installed networks and the greater number of companies providing this speed range.

Figure 36: Average SCM Price/GDP Per Capita – OECD Ranges



In the 100 to 250 Mbps range, no offers were observed in the Anatel Search for Offers only in 2025, up to the cutoff date established for the preparation of this report. However, it is worth highlighting that the average prices charged in this speed range were already close to the target set by the ITU Broadband Commission for Sustainable Development for the year 2024, reaching an average price/GDP per capita ratio of 1.83%. With the entry into force of Anatel Resolution No. 765/2023 – General Regulation of Consumer Rights for Telecommunications Services – a greater number of offer registrations is expected in Anatel Search for Offers, due to the provisions of article 21 of said regulation, which requires the registration of offers in Anatel's system before their commercialization.

The largest drop in the Average Price/GDP per capita ratio was observed in the 250 to 600 Mbps speed range, with a reduction of 71.28%, which may reflect the increase in offers in this speed range in recent years.

The smallest reduction was observed in the speed range above 1000 Mbps, which fell by 17.54% between 2021 and 2025. However, a greater reduction in these values is expected in the coming years, as an increase in commercial offers at this speed has been observed, due to the increased capacity of installed networks and the greater number of companies providing this speed range.

However, the projected declines in the Average Price/GDP ratio for the coming years may be mitigated by the lower economic growth forecast for 2026. The current growth projection for 2026 is 1.87%, while the expected growth for 2025 is 2.18%.

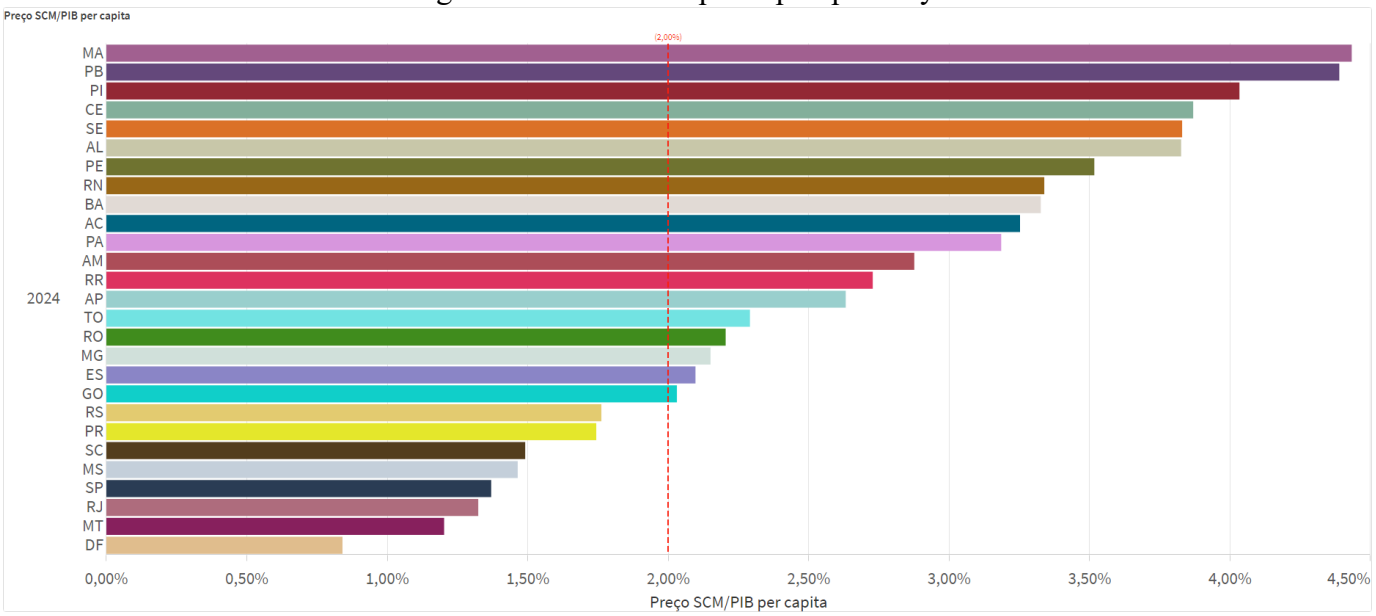
Finally, Figure 36 above demonstrates that for the speed range of 2 to 25 Mbps, the ITU's proposed benchmark was already reached in 2022, since the average price/GDP per capita ratio for that year in that range was 1.97%. For the range of 25 to 100 Mbps, the target was almost reached in 2025, with the average price/GDP per capita ratio at 2.23%.

Figure 37 below sought to demonstrate the SCM Price/GDP per capita relationship by Federative Unit (UF). For the SCM price, a nationwide offer was used, representing the lowest price registered in Anatel's Search for Offers, from a company with Significant Market Power in the fixed broadband market. The offer that met these criteria was from Claro S.A., priced at R$ 84.90, with a download speed of 125 Mbps. The monthly GDP per capita for each state was estimated using GDP data for each state at current prices from 2022, divided by the resident population in each of these states that year. Subsequently, projected growth for each state in 2023 and 2024 was calculated using the average growth observed in the period from 2010 to 2022 for each state. After that, the estimated GDP per capita for 2024 for each state was divided by 12 to obtain the monthly estimate.

It was observed that only 8 states meet the benchmark set by the ITU Broadband Commission for Sustainable Development, namely, the Federal District, Mato Grosso, Rio de Janeiro, São Paulo, Mato Grosso do Sul, Santa Catarina, Paraná, and Rio Grande do Sul. The Federal District has the lowest SCM Price/GDP per capita ratio, at 0.84%.

The Northeastern states have the worst SCM Price/GDP per capita ratio, with Maranhão having the worst SCM Price/GDP per capita ratio at 4.43%.

Figure 37: SCM/GDP per capita price by state



b) Mobile Telephony (SMP)

Regarding SMP, it is important to clarify initially that the data allowance range of less than 1 GB was removed from the price analysis, since the offers listed there are below the minimum standard established for defining a basic mobile broadband offer, which must include a monthly allowance of 2 GB, with a minimum speed of 256 kbit/s and 3G technology or higher. Besides, it is worth remembering that the use of prepaid offers with a validity period of more than 28 days in this study would affect the average price charged in the data allowance range of less than 1 GB, since the number of offers analyzed in that range would be reduced.

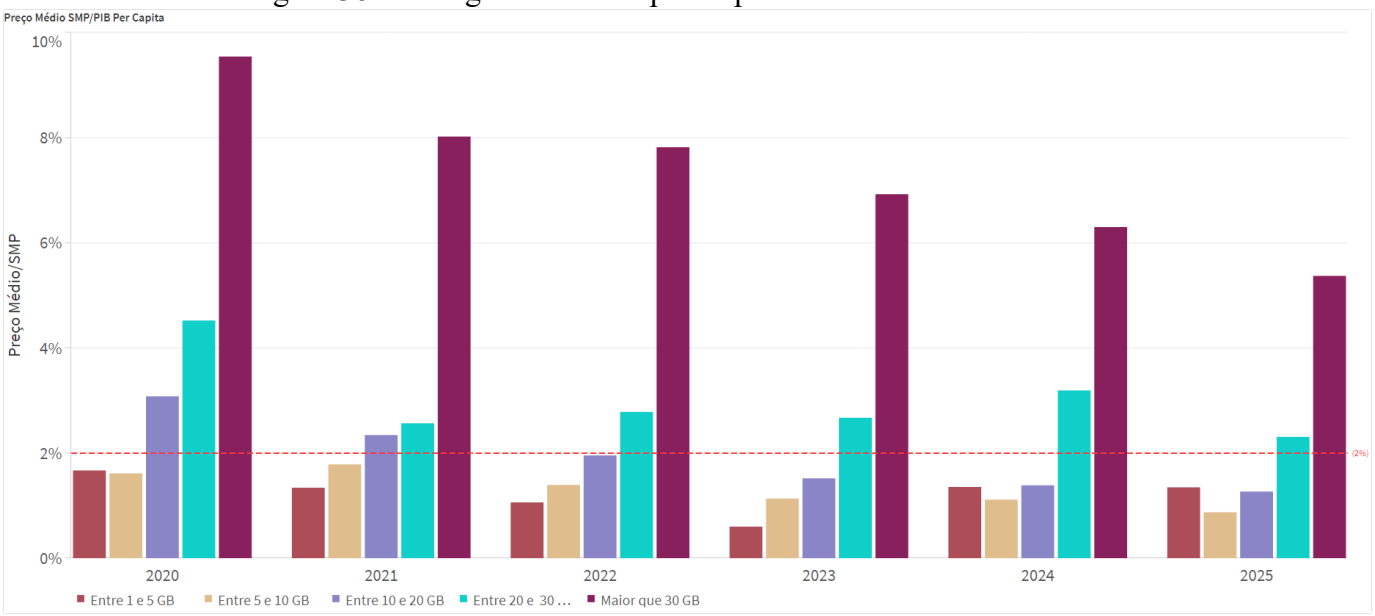
Regarding the results found concerning prices by data allowance range for SMP offers, as already verified in the PERT – Pós CP Plan (EIS nº 13064945), there is a better scenario than that observed in fixed broadband (SCM). This result is consistent with the level of maturity of the SMP market in the country, with already consolidated companies, greater 4G spread in the country, expansion of 5G, service and coverage targets, which is reflected in the prices practiced in all allowance levels analyzed.

Between 2020 and 2025, the data allowance ranges of 1 to 5 GB, 5 to 10 GB, and 10 to 20 GB have an average price-to-GDP ratio per capita lower than the target set by the ITU. The average reduction in this ratio for all data allowance ranges analyzed was approximately 43.36%. The largest reduction was in the 10 to 20 GB data allowance range, which saw a 58.8% decrease in this ratio during the analyzed period. Another notable reduction in the Average Price/GDP per capita ratio was in the 5 to 10 GB data allowance range, which fell by 48.92% during the period.

However, data from 2023 onwards shows a scenario of relative stability in price decreases by allowance ranges, with the 1 GB to 5 GB allowance range showing an increase in relative prices between 2023 and 2025. In this range, the observed increase was 18.85%. The variation in this price range can be explained by the methodology used, which did not include prepaid offers with credit validity of less than 28 days. Also, the price increase may also be a result of the providers' business model of including additional services in specific offers.

In the other allowance ranges, there was a reduction in the average price/GDP per capita ratio in the period from 2023 to 2025, but to a lesser extent than that observed in the period from 2020 to 2023. The average reduction in these ranges during the period was 18.86%.

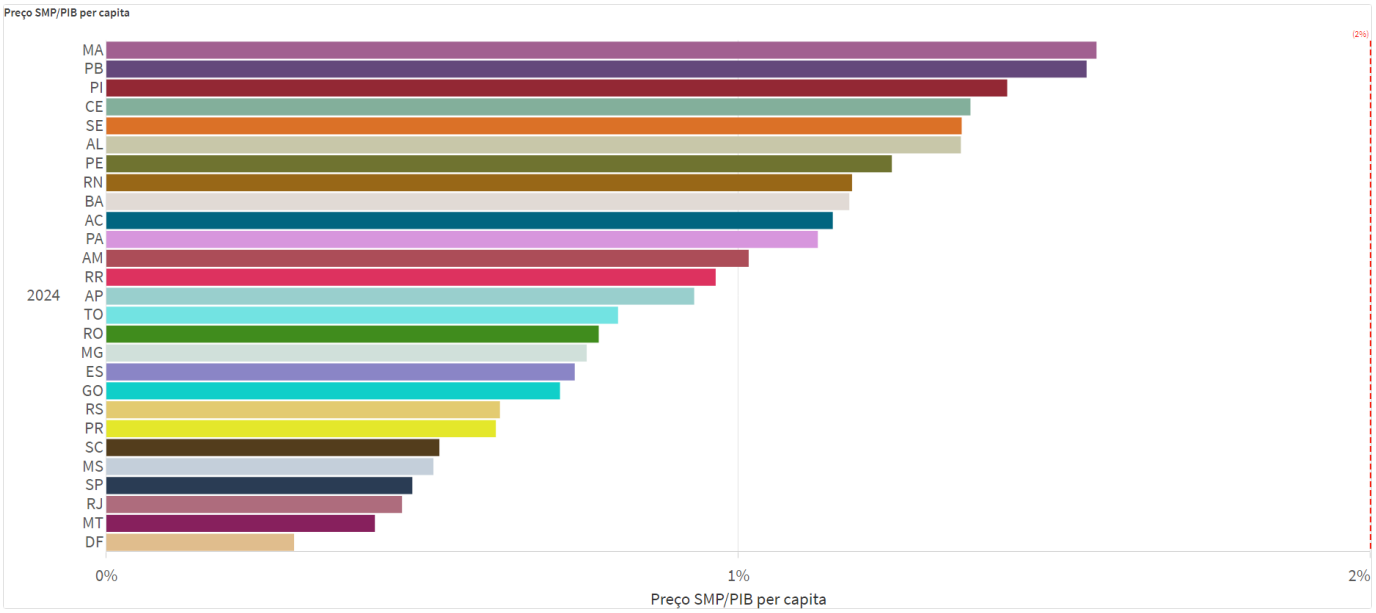
Figure 38: Average Price/GDP per Capita SMP Offer - Data Allowance



The relationship between SMP Price/GDP per capita by state is shown in Figure 39. For the SMP price, a nationwide offer was used, with the lowest price recorded in the Anatel Search for Offers, from a company with Significant Market Power in the fixed broadband market. The offer that met these criteria was from TIM Celular S.A., a postpaid plan, for R$ 30.00, with a 5 GB data allowance. The monthly GDP per capita for each state was estimated using the criteria described earlier in the fixed broadband analysis.

It was observed that in all states, the cost of the chosen entry-level offer in the study is less than 2% of GDP per capita, demonstrating the greater accessibility of mobile broadband for the Brazilian population.

Figure 39: Price of Entry SMP/GDP per capita by State – 2024



Price comparison with other countries in Latin America, the Caribbean and the OECD

To compare the results obtained in Brazil with some OECD and Latin American and Caribbean countries, the ITU ICT Price Baskets 2024 for those countries were used.

The comparison was made using Brazil's Price/GDP per capita ratio, calculated from the entry-level offers defined for fixed broadband and mobile broadband in 2024, with the data available in the ICT Price Baskets for those countries.

The results demonstrate that both fixed broadband and mobile broadband in Brazil have a Price/GDP per capita ratio of less than 2%, within the target set by the ITU Broadband Commission for Sustainable Development.

Figure 40: Price offer/GDP per capita Fixed Broadband - OECD 2024

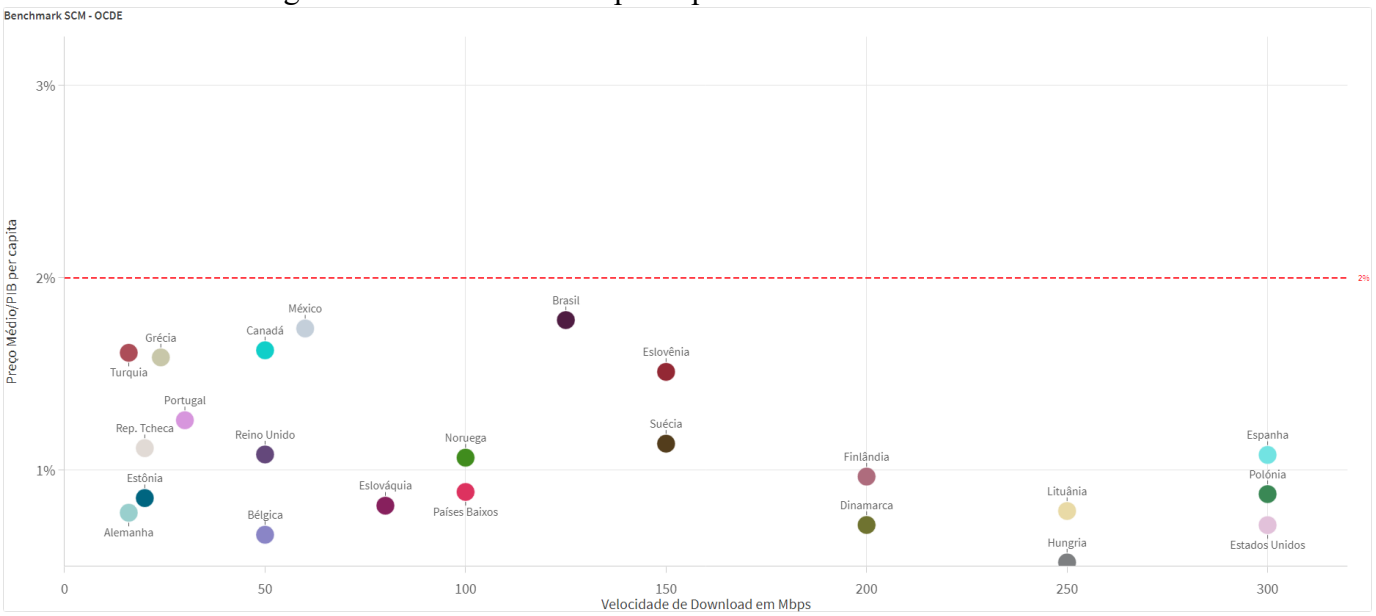


Figure 41: Price offer/GDP per capita Fixed Broadband – Latin America and the Caribbean – 2024

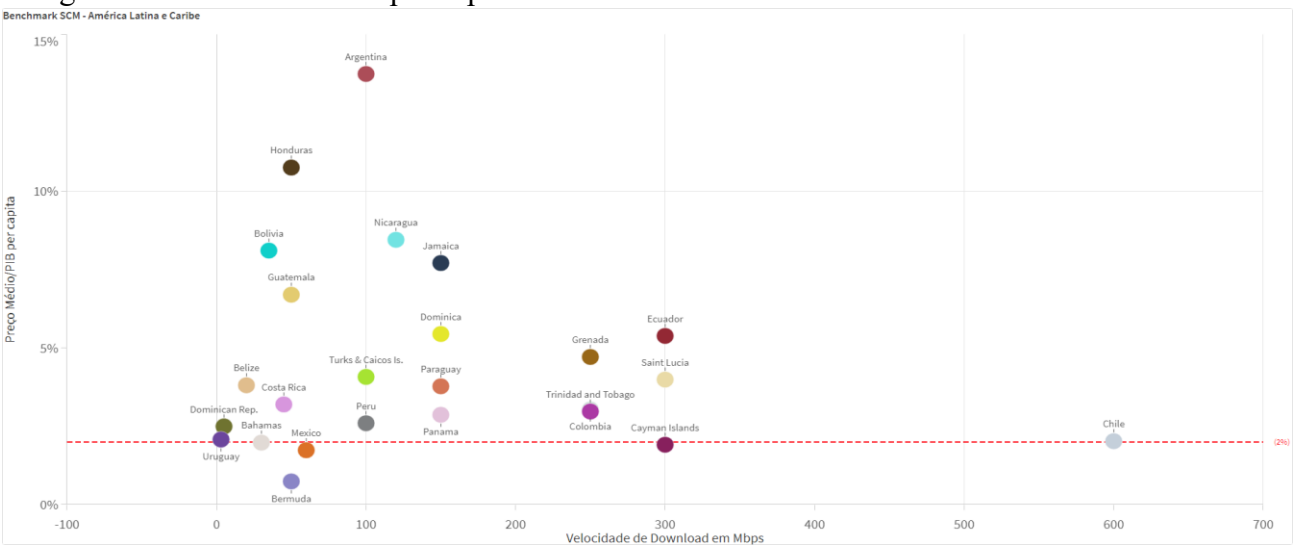
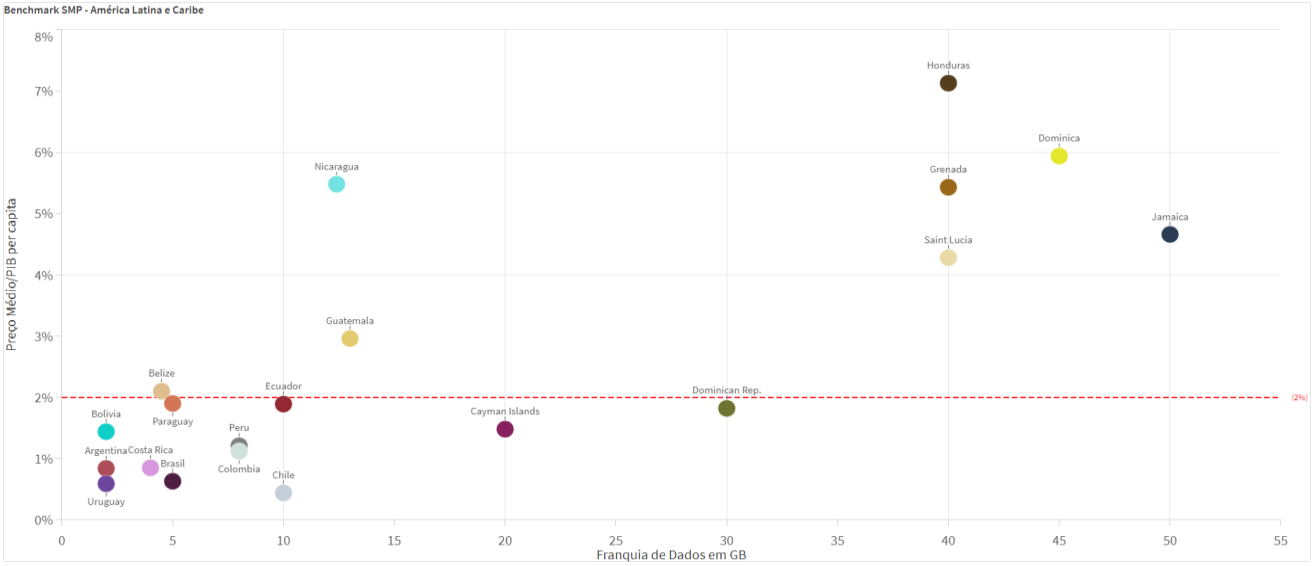


Figure 42: Price offer/GDP per capita Mobile Broadband - OECD 2024

Figure 43: Price offer/GDP per capita Broadband – Latin America and the Caribbean - 2024



5. Devices for Meaningful Connectivity

Quality - Influence of Devices by Low-End, Mid-End and High-End range on the quality of user experience.

Users' mobile devices vary in terms of their technical characteristics, which can influence their performance and, consequently, the quality of the user experience when accessing services.

In this context, Anatel conducted a study, documented in Inspection Report No. 20/2022/GR05FI1/GR05/INS (EIS 8273515), with three main objectives:

- To determine whether the distribution of devices in Brazil differs from international standards;
- To determine if there are indications of differences in performance by device category; and
- To determine if there is evidence that performance in Brazil is impacted by device categories.

For the study, an economic criterion was used to classify the devices into three categories:

Category	Price (USD)
Low-end	Less than 150
Mid-end	Between 150 and 550
High-end	Greater than 550

Additionally, a technical criterion was used, based on the technical characteristics of the devices.

The data used was from the Speedtest Intelligence tool, obtained through a Technical Cooperation Agreement signed between Anatel and the company Ookla.

At the end of the study, carried out by teams of inspectors from different Decentralized Units of Anatel, some assessments and conclusions were reached in order to answer the proposed questions, as described below.

According to the economic criteria for classifying devices adopted in the studies, it is clear that the social/economic factors of each country are directly linked to the issue of device distribution in different countries. Based on the data presented, it is possible to see that the distribution pattern of devices by category in Brazil is much more aligned with that of other countries that are most similar, from an economic point of view, such as Argentina, Mexico and Russia, than with the pattern presented by rich/developed countries, such as Germany and the USA - in which the quantity of "high-end" devices is significantly greater than in the countries of the first group.

Based on the adopted technical criterion, which uses the concept of "Modern Chipsets/Devices" category provided by the Speedtest Intelligence tool itself, it is again concluded that

there is a greater similarity in the distribution patterns of terminals by category in Brazil and related countries, when compared to the pattern presented by developed countries.

Specifically regarding the national context, there tends to be a greater concentration of higher-category terminals in the Federative Units that have higher "GDP per capita" rates.

Based on the economic criteria for classifying devices, there is a direct relationship between the category of the devices and their performance: the higher the category, the higher the average download and upload speeds and the lower the latency.

Based on technical criteria, "Modern Chipset" devices offer superior performance compared to LTE devices.

Regarding the Brazilian scenario, regardless of the state in which the different devices were tested, the performance presented by "Modern Chipsets" is always superior to 4G LTE devices.

Regarding the Brazilian scenario, according to detailed data by state, it seems evident that, in general, tests performed on "Modern Chipsets" category terminals show better measurements than those performed on LTE terminals, presenting higher download and upload speeds, as well as lower latency rates.

Besides, it is possible to verify that countries with similar device distribution patterns (LTE x Modern Chipset) to Brazil – such as Argentina, Mexico, and Russia – also exhibit similar performance levels – average speeds and latency. However, for countries where the number of Modern Chipset terminals exceeds that of LTE technology – such as Germany and the USA – average speed rates increase significantly, while latency decreases slightly.

Devices safety - Product certification, accreditation of specialized laboratories, and supply chain security.

Anatel has been conducting actions aimed at evaluating the cybersecurity of telecommunications products and their suppliers, culminating in the publication of the following documents:

• Cybersecurity Requirements for Telecommunications Devices, approved by Act No. 77, of January 5, 2021:

> Establishing cybersecurity requirements for telecommunications Devices must consider a diverse ecosystem in which a multitude of devices have multiple applications. These requirements should be broad in scope while still taking into account the specific characteristics of each product and the criticality of its potential applications in relation to the security of the user and the telecommunications networks to which they belong or which they connect.
>
> Considering this scenario, Act No. 77/21 was developed as a set of cybersecurity recommendations for telecommunications Devices manufacturers to be applied during the product development stages. As these are recommendations, they are not mandatory for obtaining product approval from Anatel.
>
> With the aim of promoting the adoption of the recommendations of Act No. 77/21 by manufacturers, Anatel requires that those interested in the homologation of Devices submit,

along with the results of the product certification tests, a declaration stating which safety recommendations of Act No. 77/21 the product meets.

The declaration must consider the different technical characteristics of the Devices (amount of memory, data processing capacity, user interfaces, communication interfaces, etc.) and the purposes for which they are intended. If the product does not meet certain recommendations, the manufacturer must provide the necessary technical justifications; this fact is not an impediment to obtaining product approval.

Act No. 77/21 provides that the Agency may carry out market supervision activities in which the Agency will collect Devices from the market and verify, through laboratory tests, whether the Devices actually meets the safety recommendations stated in the declaration that was submitted to Anatel during the product approval process.

In order to protect consumers and ensure the integrity of the country's telecommunications network infrastructure, if the inspection process identifies that telecommunications Devices, or its supplier, presents any non-compliance with the recommendations of Act No. 77/21 that may affect the safety of the user or telecommunications services, the Agency will notify the party responsible for the approval to correct the fault, indicating an appropriate deadline for this purpose, considering the degree of risk of the vulnerability.

If the deadline passes without the necessary adaptations being made or without Anatel accepting the justification for their non-implementation, the Agency will suspend the product's approval and may recommend its recall or replacement in the market, while guaranteeing all other regulatory provisions related to consumer rights.

• Mandatory minimum cybersecurity requirements for compliance assessment of CPE (Customer Premises Devices), approved by Act No. 2,436, of March 7, 2023:

The motivation for creating these requirements was the perception that many of the CPE devices distributed in the national market have a vulnerability in their default authentication configuration. This vulnerability, which consists of the factory setting of identical authentication passwords across all manufactured Devices units, allows malicious subjects to easily access the Devices's configuration environment via the Internet and take control of those CPEs whose default passwords have not been changed. Such intrusions can result in the compromise of information (personal, banking, etc.) of users of telecommunications services, in addition to allowing such CPEs to be used as vectors in denial-of-service attacks or other types of cyberattacks.

The proposal to define minimum cybersecurity requirements to be evaluated in the CPE certification process ensures that all Devices approved by Anatel is distributed to the market without the vulnerability of standardized passwords, guaranteeing greater security for consumers, who, in most cases, do not have the technical knowledge to change the access passwords of their Devices.

• Technical requirements for type conformity assessment of Smart TV Box products, approved by Act No. 9281, of July 5, 2023:

With the aim of contributing to minimizing the supply of products that promote informal access to audiovisual content and which, in many cases, have cybersecurity vulnerabilities that put their users at risk, the Agency has developed requirements for Smart TV Box certification.

In addition to requiring verification of the ability to provide unauthorized access to content protected by copyright law, the requirements demand that Smart TV Boxes be tested for the presence of any form or service of undocumented communication (port), in accordance with items 5.1.5 b) and c) of the Cybersecurity Requirements for Telecommunications Devices approved by Act No. 77/2021. The presence of improperly opened communication ports on Devices allows for the intrusion of users' networks, putting their personal data at risk.

• Operational procedure for the qualification of entities specialized in cybersecurity assessment of telecommunications products, approved by Act No. 14884, of October 16, 2024:

Cybersecurity requirements for the certification and approval of telecommunications Devices have recently been incorporated into Anatel's product conformity assessment program.

As a result, the testing laboratories authorized by the Agency to participate in this program are still working to enhance their capabilities, particularly with regard to tools and techniques for conducting more complex cybersecurity tests.

In order to enable the Agency to draw on the expertise and services of entities with greater specialization in cybersecurity assessments, an operational procedure has been published for the accreditation of entities specializing in cybersecurity assessments of telecommunications products.

This procedure establishes the minimum conditions and requirements necessary for the qualification of entities specialized in performing, among other activities: penetration testing; identification and analysis of new attacks (zero-day exploit); study of the source code of Devices software/firmware; analysis of the structure of stored files; monitoring of data connections established by the Devices; and evaluations of the behavior of its functionalities.

The purpose of these entities is to identify vulnerabilities in Devices such as: backdoors, malicious code and applications, leaks of sensitive information, program errors, and others that may jeopardize the security of telecommunications networks and, above all, the users of the products.

The authorization of such specialized entities is primarily intended for activities related to market supervision, in which the cybersecurity of products available to consumers is evaluated.

• Operational Procedure containing guidelines for auditing the cybersecurity policy of suppliers of telecommunications products and Devices for service providers, approved by Act No. 16417, of November 22, 2024:

Article 7 of the Regulation on Cybersecurity Applied to the Telecommunications Sector, approved by Resolution No. 740 of December 21, 2020, establishes that service providers must use, within their networks and services, telecommunications products and Devices from suppliers that have cybersecurity policies compatible with the principles and guidelines set forth in the Regulation and that carry out periodic independent audit processes.

The second paragraph of this article defines that it is up to the Cyber-WG to determine the formal and procedural aspects related to the implementation of this measure.

In this regard, the Cyber-WG Technical Subgroup on Devices, Suppliers and Requirements, which brings together more than 200 representatives from different sectors, including industry, service providers, academia, testing laboratories, certification bodies, government and Anatel, mobilized to develop and discuss a proposed rule for service providers to comply with Article 7.

The discussions were organized in two stages. The first focused on the development of the Cybersecurity Policy (CSP) for suppliers, resulting in a document approved by the Cybersecurity Working Group through Decision Order No. 16/2023/COQL/SCO. This document established the basic principles of CSP to be adopted by service providers, including: security by design, security by default, privacy by design, security updates, and communication channels for vulnerability notification.

In the second stage, the subgroup developed a proposed set of guidelines for auditing this supplier CSP, which was constructed over the course of six meetings.

The final, agreed-upon text was submitted for public consultation and subsequently published by SOR through Act No. 16417, dated November 22, 2024.

These guidelines, based on internationally recognized frameworks and standards, aim to guide auditing entities and suppliers on the audit evidence needed to demonstrate the implementation of CSP in suppliers' internal processes.

The document also specifies which entities can conduct the audits, ensuring credibility and international alignment.

Cybersecurity is a topic closely associated with meaningful connectivity, given that achieving this level of connectivity requires not only a developed and protected telecommunications infrastructure, but also that consumers have access to appropriate devices that ensure secure and high-quality access to the connected world.

6. Skills

Specifically regarding skills, and in line with SDG 4.4, the ITU aims for 70% of individuals to possess basic digital skills and 50% intermediate skills by 2030. The definitions and methodologies for measuring these digital skills have been internationally agreed upon and are available in the "Manual for Measuring ICT Access and Use by Households and Individuals".

They are divided into three categories: basic, intermediate, and advanced.

Basic skills include:

i. copying and moving files or folders;

ii. using copy and paste tools to duplicate or move information within documents;

iii. sending emails with attached files; and

iv. transferring files between a computer and other devices.

Among the intermediate skills, we have:

i. using basic arithmetic formulas in spreadsheets;

ii. connecting and installing new devices;

iii. creating electronic presentations using presentation software; and

iv. finding, downloading, installing, and configuring programs and applications.

Advanced skills include:

i. the development of computer programs using specialized programming languages.

These latter (advanced) skills are not included in the 2030 targets.

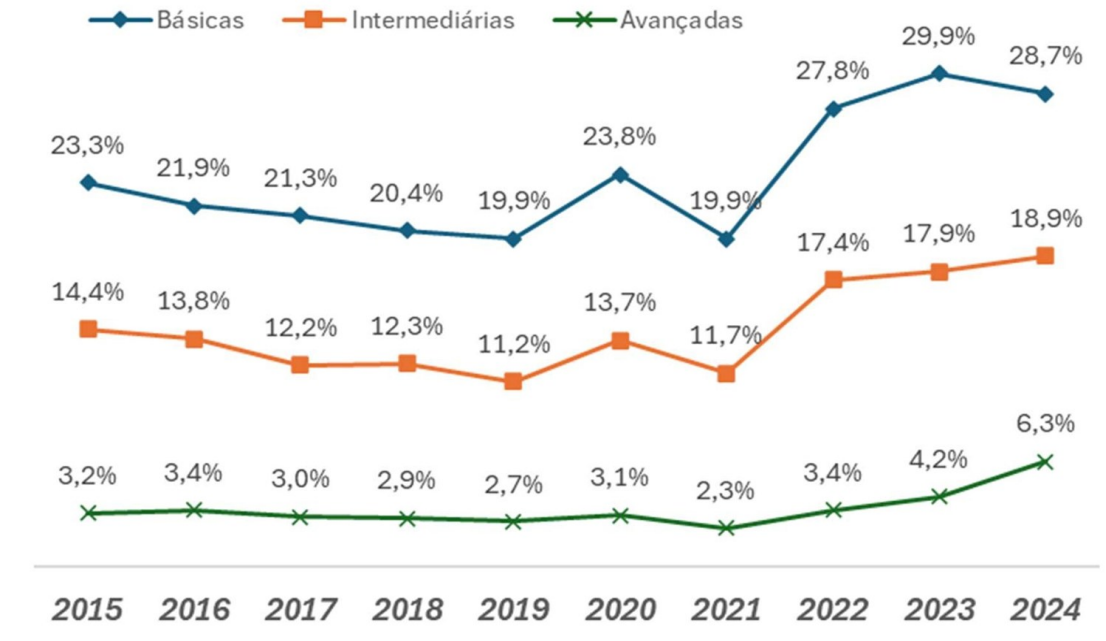
Following the guidelines proposed by the ITU, Anatel included in its "Strategic Plan for the Period 2023-2027"[36] a series of commitments and goals related to meeting the pillars of universal and meaningful connectivity in Brazil.

Regarding the promotion of digital literacy and the development of digital skills and abilities, the Agency's target is that, by 2027, 30% of young people and adults will possess moderate skills in Information and Communication Technologies (ICT). This indicator is monitored through the ICT Households survey, which uses internationally defined methodological standards and indicators as a reference.

The study Digital Skills in Brazil and the World – produced by Anatel, through the Superintendency of Consumer Relations (SCR) and the Management of Institutional Interactions, Satisfaction and Consumer Education (RCIC) – conducts a diagnosis of digital skills, based on the levels described above. Figure 44 shows the proportion of people with each level of digital skills over time.

[36] https://www.gov.br/anatel/pt-br/acesso-a-informacao/acoes-e-programas/planejamento-estrategico

Figure 44: Basic, intermediate, and advanced skills in Brazil (2015 to 2024)



Source: reproduced from the study "Digital Skills in Brazil and the World" (2015 to 2023) with updated data from 2024 based on the results of the ICT Households survey from the same year.

The study also presented two main axes. One of them contextualizes Brazil in relation to several countries that have the same data. From this perspective, the study demonstrates that the country needs to intensify its initiatives to promote digital skills in order to position itself among the 20 most developed nations in this aspect.

The other axis presents the state of digital skills in the country through breakdowns such as gender, region, social class, among others. The following highlights appear in this analysis:

- the population residing in rural areas proportionally possesses fewer digital skills than the population in urban areas;
- the Northeast region has the lowest proportions of the population with digital skills at all levels (basic, intermediate, and advanced);
- women not only possess fewer digital skills than men, but they also show slower progress and, when considering advanced skills, even negative progress between 2022 and 2023 – although a further reduction in this difference was identified between 2023 and 2024;
- regarding education level, social class, and income level, it is observed that, in general, the higher these factors, the greater the proportion of people with digital skills;
- regarding age range, the elderly are the subgroup with the lowest rates of basic, intermediate, and advanced digital skills.
- Indigenous, Asian, and Black populations have fewer basic, intermediate, and advanced skills, respectively.

It is also important to highlight that the European Union is today one of the main international references in this field. Through DigComp 2.2 – The Digital Competence Framework for Citizens, a

robust framework was established that organizes digital competences into five main areas, offering a common language and practical examples of knowledge, skills, and attitudes.

This framework serves as a basis for public policies, school curricula, professional training strategies, and digital inclusion initiatives for different audiences. It is also the benchmark used by the ITU to reformulate digital skills indicators, which are currently being adopted by countries. In this sense, the categorizations presented here (basic, intermediate, and advanced skills) will cease to exist, and the number of indicators will increase, becoming aligned with the DigComp areas of competence.

- Information and Data Literacy;
- Communication and Collaboration;
- Digital Content Creation;
- Protection;
- Problem Solving.

Since the target in Anatel's Strategic Plan has not yet been updated to reflect this new configuration of digital skills indicators, this assessment focuses on the previous configuration. Although the new methodology measures digital skills in a more comprehensive way, the measurement used for the results presented here represents a subset of the broader measurement. Therefore, continuing with the current framework until the strategic plan is updated does not necessarily imply any detriment to the implementation of initiatives to promote digital skills in the country.

Enhancing the digital skills of the population through the development of their digital competencies

Digital skills encompass the practical, conscious, and efficient uses and applications of digital technologies. It is about "knowing how to do"—that is, what knowledge is needed and how to correctly apply it to perform specific tasks and solve problems within the digital ecosystem. For example, sending a document to the cloud, setting up a printer, and sharing a contact, in addition to those mentioned above.

Given their practical nature, digital skills are generally not improved directly, but developed in conjunction with other dimensions of digital competencies.

In this vein, the "tripod of competencies" is a well-known and widely used model for mapping, evaluating, and developing personal and professional skills and qualifications. It proposes three essential dimensions to represent people's development – Knowledge, Skills, and Attitudes ("KSA") – and can be easily applied in the digital context.

Thus, in relation to the set of **Digital Competencies**, in addition to the "know-how" of Digital Skills, already mentioned, **Digital Knowledge** represents the information assimilated through study and learning and experiences in cyberspace. For example, knowing the differences between mobile networks and Wi-Fi networks, and being aware of consumer rights regarding telecommunications services.

Digital Attitudes are related to practices, behaviors, ethical values, and proactivity/co-creation in the online environment. Cybersecurity and online safety are closely linked to user behavior, in the sense that it is not enough to simply be aware of risks and threats—users must also adopt an

attitude that enables them to recognize and avoid these risks (readiness). Thus, using strong passwords and avoiding clicking on unknown links are examples of best practices that users should adopt.

The European Union is today the leading reference point in terms of developing digital skills. It adopted a framework – DigComp 2.2 The Digital Competence Framework for Citizens (CE, 2022)[37] – for the development of its citizens' digital skills. The model provides a common language, with many examples of knowledge, skills, and attitudes, to be used in the formulation of digital policies, educational planning, and professional training for citizens in general and specific target audiences.

Along the same lines, Anatel has the capacity to contribute to the creation of an environment conducive to the development of digital skills and abilities among the Brazilian population. Also, the Agency can enhance regulatory stances and education and empowerment initiatives that promote the development of digital skills among consumers of telecommunications products and services, in order to make the consumer relationship and satisfaction with services more positive.

Digital Literacy

Ensuring universal and meaningful access to telecommunications services and promoting digital inclusion are priority objectives in many countries. Several projects and initiatives are being developed to reduce the digital divide and provide adequate infrastructure in underserved areas, both urban and rural, as well as low-income communities. Equally common are initiatives aimed at establishing digital inclusion programs for marginalized groups; including schools and educational centers as connectivity hubs; and developing projects to improve digital literacy and basic digital skills, aiming for the full utilization of Internet resources. In all of them, the development of digital skills occupies a central position. Even in projects aimed at reducing taxes on components and Devices used for internet access, for example, there are opportunities to optimize significant connectivity through user awareness and the development of these skills in consumers.

Programs and initiatives like these are closely related to policies of social inclusion, digital inclusion, employment, and professional training, to name just a few that are found in broader areas than the direct sphere of duties and responsibilities of the telecommunications regulator. In these situations, Anatel can contribute directly and indirectly, with information and awareness campaigns, studies and publications (there are several materials available on the Agency's website), as well as collaborate in the development and dissemination of projects, events and experiences, such as Girls in ICT Day and Cybersecurity October, for example.

Also, Anatel has developed internal initiatives to promote consumer education and awareness campaigns about consumer rights and online risks and threats. In the new context of meaningful connectivity, these initiatives should be guided by a strategic focus aligned with the development of digital skills, so that digital literacy complements the widespread dissemination of information on consumer rights and best practices for online protection.

[37] EUROPEAN COMMISSION. DigComp 2.2: The Digital Competence Framework for Citizens. Publications Office of the European Union. Luxembourg, 2022.

Research on Meaningful Connectivity

One of the most important ongoing actions is conducting a national survey on Meaningful Connectivity[38], to obtain information about the experience of using the Internet via mobile phones and fixed broadband networks by consumers of telecommunications services. In particular, the aim is to assess issues relating to the enjoyment and consumption of services, access to public policies, the devices used to access the network, as well as the main profiles of online activities carried out.

A more detailed understanding of the knowledge and behaviors of telecommunications consumers will help in the analysis and development of instruments for defining and adopting guidelines, references, and actions for building the digital skills and competencies of telecommunications consumers.

Digital Skills of Telecommunications Consumers

The telecommunications consumer occupies a central position in the Agency's efforts to promote digital literacy. That is, from the planning to the execution of projects and initiatives, everything must be geared towards their language, journey, priorities, and experiences, with the goal of providing an environment that fosters the learning of the digital skills/competencies that are necessary and important for their awareness, emancipation, and empowerment within the digital ecosystem.

There are at least two good reasons for choosing the consumer as the central focus. The first has to do with the fact that telecommunications services are the gateways to the digital ecosystem. Promoting consumers' digital skills and abilities enables them to enter cyberspace more aware and prepared for the risks, challenges, and opportunities of this environment. This logic applies even to future or potential consumers of telecommunications services, that is, those who are still very young or those in the process of digital inclusion.

Besides, the digital skills acquired by these consumers have a ripple effect on all social interactions and consumer relationships in the digital environment. That is, by becoming more aware, prepared, and demanding of telecommunications services, they are also acquiring important knowledge and experiences that can be applied to other areas of the digital world, such as content portals, e-commerce platforms, and digital services.

[38] https://www.gov.br/anatel/pt-br/assuntos/noticias/anatel-divulga-pesquisa-de-conectividade-significativa-com-foco-em-dispositivos-habilidades-e-franquia-de-dados

7. Cyber Security and Critical Infrastructure Protection

Regulation and Governance of Cybersecurity and Critical Infrastructures

The protection of Critical Infrastructure (CI) has always been a major concern for Anatel since its inception, initially focused on the physical protection of stations and ensuring the availability of resources for their operation in cases of disasters and emergencies. Over the years, cyber risks have become an increasingly relevant risk category, leading the Agency to issue the Cybersecurity Regulation Applied to the Telecommunications Sector (Cyber-R), approved by Resolution No. 740, of December 21, 2020.

Cyber-R establishes a set of principles and guidelines that apply to all actors in the telecommunications sector and a set of *ex ante* controls that are imposed on telecommunications service providers with Significant Market Power (SMP), that is, companies from the Claro, Oi, Tim, Sky, and Vivo Economic Groups. These obligations aim to ensure that these companies have adequate governance over these risks; that the supply chain is protected; that frequent vulnerabilities related to Devices authentication are addressed; that vulnerability assessment cycles are carried out; that Anatel can have a diagnosis of incidents in the sector and of CI; and that, finally, an ecosystem for sharing information on threats, vulnerabilities, and incidents is built in the sector.

Cyber-R also establishes how sectoral governance of the topic will be carried out, instituting the Technical Group on Cybersecurity and Critical Infrastructure Risk Management (Cyber-TG). Cyber-TG has an extensive range of responsibilities, including monitoring the implementation of obligations; preparing detailed ex-ante controls; sharing information and best practices; promoting awareness and training initiatives; conducting studies and interacting with the Brazilian Communications Commissions (BCCs), responsible for representing Brazil in international telecommunications organizations. One of Cyber-TG's key responsibilities is to drive initiatives focused on service providers that do not hold SMP certification, ensuring that its principles and guidelines are properly observed.

It should be clarified that, in addition to initiating the Cyber-R implementation process, Cyber-TG, in compliance with the Board of Directors' decision, began discussing the need to expand *ex ante* control to other telecommunications service providers not currently obligated to do so. These discussions led to a proposed amendment to Cyber-R, which was submitted for public consultation, with the aim of encompassing critical infrastructure for connectivity in Brazil, especially considering the critical role of certain subjects in the ecosystem. Recently, in mid-July 2024, the Board of Directors deliberated on this expansion of the scope of ex ante control, which now includes submarine cable operators with international destinations; Personal Mobile Service providers with their own network; and network operators that offer traffic in the wholesale market belonging to economic groups classified as SMPs in the High-Capacity Data Transport Market, according to the General Competition Goals Plan (GCGP).

Alsoe, all service providers of collective interest must comply with Article 8 of Cyber-R, which seeks to address the authentication vulnerability of Devices provided to consumers for home use. Another obligation that now covers all telecommunications service providers is the notification of Anatel in cases where the National Data Protection Authority (NDPA) is required to report a security incident, so that Anatel can diagnose incidents involving personal data in the sector.

Cyber-TG is coordinated by the Superintendent of Obligations Control, appointed by Anatel Ordinance No. 1,878, of December 30, 2020, initially including the participation in the plenary of service providers holding Significant Market Power (PMS), as well as an entity representing Small Service Providers (PPPs). With the revision of Cyber-R, it is determined that all service providers subject to *ex ante* control participate in Cyber-R. Furthermore, the group may include invited guests, depending on the topic to be discussed, enriching the debate with the participation of multi-sectoral groups and discussions.

With Cyber-R, all risk management of critical infrastructures is managed by the designated service providers in their Cybersecurity Policy (CSP), which is nothing more than the tool by which the providers will ensure adequate governance of the subject, including the procedures and controls adopted for the identification and analysis of vulnerabilities, threats and risks associated with critical infrastructure and service continuity, as well as the procedures and controls adopted for mitigating these vulnerabilities. However, it should be noted that Contingency Plans for disaster situations and the National Emergency Network of Telecommunications Providers (NENTP) are regulated by a different set of regulations, specifically the Regulation on the Use of Telecommunications Services in Disasters, Emergency Situations and States of Public Calamity, approved by Resolution No. 739, of December 21, 2020.

Since the approval of Cyber-R in 2020, the Agency has promoted, within the framework of Cyber-TG, a process to detail how *ex ante* controls would be operationalized and reported to the Agency. This initiative resulted in the Operational Procedure with guidelines for auditing the cybersecurity policy of suppliers of telecommunications products and Devices for service providers (Act No. 16417, of November 22, 2024). Besides, a premise of the definitions approved within the scope of Cyber-TG is precisely that all decisions require constant reassessment, especially considering the dynamic nature of the phenomenon.

Paralelamente, a Anatel vem acompanhando as obrigações já implementadas, com o objetivo de garantir que atinjam sua finalidade em processos de Fiscalização Regulatória, os quais podem abranger inclusive ações de inspeções.

Regarding Cyber-R, Anatel's strategy of continuous evolution was consolidated with the formalization of a priority item in the **Regulatory Agenda for the 2025-2026 biennium.** This initiative, stemming from a decision by the Board of Directors in February 2024, mandates a new and thorough reassessment of the Regulation to proactively address new threat vectors and critical points. The ongoing regulatory impact analysis covers topics such as the malicious application of artificial intelligence solutions, vulnerabilities in new network layers (such as quantum and virtualized networks), and, crucially, the definition of regulatory aspects for the provision of cloud computing and data center services when intrinsically linked to the telecommunications sector, assessing the Agency's competence for direct regulation and its intersection with environmental sustainability (SDG 9).

Materializing the shift from standardization to technical capability, the Board of Directors, in deliberations throughout the first half of 2025, approved the advancement of the project to create a **Cybersecurity Testing Center and Laboratory for Anatel**. This structure, to be implemented in partnership with academic institutions and other government agencies, will have the central objective of evaluating Devices, conducting forensic incident analysis, promoting penetration testing (pentests)

on critical infrastructures, and providing advanced technical support to Cyber-TG and its oversight activities. The initiative is a direct response to the need to verify, in practice, the compliance of products and networks with established security requirements.

Additionally, confirming the priority of the topic in its long-term planning, the **Agency's Strategic Plan for the period 2023-2027** continues to guide all these actions through Initiative 7 ("promoting holistic risk management and the protection of critical infrastructure"). Both the upcoming review of Cyber-R and the implementation of the lab are direct tactical outcomes of this strategic objective, which aims not only to create rules, but also to build an ecosystem of cyber compliance and resilience in the country.

With the maturation of the deadlines defined in Resolution No. 766/2024, the year 2025 marks Anatel's transition to a regime of **intensified supervision and oversight**. The service providers covered by the Cyber-R expansion had to submit their initial versions of the Cybersecurity Policy (CSP) and their action plans, initiating a cycle of continuous monitoring by the Agency. The focus now lies on verifying the effectiveness of the implemented measures, monitoring incident reports, and auditing supply chains, consolidating the regulatory framework as a fundamental pillar of the PERT 2024-2029.

Oversight

Assessing the cyber resilience of service providers—particularly with regard to the implementation of the obligations, principles, and guidelines set forth by Cyber-R, including proof-of-concept testing and inspections of telecommunications service providers, is important to ensure that cybersecurity policies and procedures are established, periodically reviewed, and aligned with technological advancements, process improvements, and the need for continuous and structured training for all employees through training and development programs.

In addition to the requirement that service providers have an incident response plan and preventive measures in place, the protection of service providers' networks is becoming increasingly important, as these are CI, and if their facilities, services, and assets are disrupted or destroyed, it will have a serious social, economic, political, and international impact, as well as an impact on national security itself.

Thus, telecommunications service providers need to have a consistent and evolving approach to cybersecurity to identify and assess vulnerabilities, and manage the risk of threats, by observing, for example, the five functions foreseen in the cybersecurity framework of the National Institute of Standards and Technology (NIST), which are: identify, protect, detect, respond and restore, which is one of the reliability benchmarks followed by agencies and organizations worldwide.

So, in accordance with Cyber-R in its article 5, I, which states: "to adopt national or international norms and standards, and references of good practices in Cybersecurity", a model or reference was sought within the Superintendence of Inspection environment to be observed in the verification and inspection needs of Anatel with the service providers.

In the corporate environment, the use of Information Technology (IT) Governance and Management is a good practice, as it ensures the organization's infrastructure support and facilitates the achievement of corporate strategies and objectives, in order to guarantee greater efficiency, with the application of metrics that help define maturity levels, certification, quality in operations, and an

active vision throughout the IT lifecycle. For this governance and management, Control Objectives for Information and related Technology (COBIT) is a tool to aid in auditing IT processes, practices, and controls within the organization.

COBIT, in its version 5, is a developed framework of documents with the main security definitions to be followed in the company, to be used as a guide for technology, processes and behavior for any and all employees who will work in the company, indicating the use of frameworks as best practices.

A framework is a series of processes used to define policies and procedures surrounding the implementation and ongoing management of information security controls in a corporate environment. This framework is basically a "model" for building an information security program to manage risks and reduce vulnerabilities. Information security professionals use these frameworks to define and prioritize the tasks necessary to improve security in an organization.

It is noteworthy that these controls form a set of actions aimed at raising the level of high-priority defense against the most pervasive cyberattacks and that, in the face of a scenario of increasing threats, they are considered essential and urgent measures for any organization that needs to improve its cybersecurity.

This set of best practices in the field of cybersecurity and protection, with numerous guides and references that can be adopted by operators within the scope of their operational capacity and maturity, is essential to meet regulations and ensure the proper protection of information and cybersecurity in the provision of their services and to their users.

This monitoring and enforcement actions are essential to provide the Agency with the knowledge, data, and evidence that will allow for the development of a comprehensive cybersecurity diagnosis in the sector.

Cybersecurity Incident Prevention

First, it is important to highlight the cyber resilience of Brazilian networks. Even with the growing expansion of the attack surface and increases in cybercrime, as well as the significant increase in traffic during the COVID-19 pandemic, Brazilian networks have demonstrated their robustness and resilience. In this regard, it should be noted that, since November 2021, Anatel has been required to be notified of relevant incidents at service providers that hold SMP, which collectively reported more than 133 incidents, 24 of which occurred during the year 2023. However, no incident caused disruption to telecommunications services. With the recent update to the Regulation, the list of entities that must notify the Agency in the event of relevant incidents is expanded, reiterating the obligation of all telecommunications service providers, regardless of size, in cases where notification to the NDPA of a security incident is required.

Given the complexity of defining what should be reported to the regulator, it was decided to work with an illustrative list of incidents that must be reported to the Agency. This list covers: data breaches (corporate or consumer); successful ransomware attacks; compromises resulting from Advanced Persistent Threats (APTs); Denial of Service Attacks (DoS/ Distributed Denial of Service - DDoS; routing problems (prefix hijacking, route leaks, and/or configuration errors) that may impact

the delivery of services to customers of providers, organizations, or entities operating on the Internet; and service unavailability caused by a cybersecurity incident.

The purpose of receiving these notifications is to provide Anatel with visibility into the occurrence of incidents on Brazilian telecommunications networks, as well as their cyber resilience. With this data, the Agency will be able to extract the necessary information to support its regulatory policies and initiatives on the matter.

Most incidents reported to Anatel relate to DoS/DDoS. This type of attack aims to exhaust the victim's resources, such as bandwidth or processing power, making a particular service inaccessible or unusable, either due to total unavailability or service degradation.

It is noticeable, due to the frequency of DoS/DDoS, that these incidents are part of the daily routine for telecommunications service providers, which have processes and technology in place to prevent and respond to these incidents, especially by adopting the necessary mitigation measures. In this regard, among the DoS/DDoS incidents that must be reported, a traffic threshold of 50Gbps and a packet speed of 20Mpps per second were established to ensure the relevance of the report.

These parameters, as well as the illustrative list, need to be constantly reassessed in order to ensure that the obligation achieves its purpose and enables the Agency to prepare the diagnosis. These discussions take place within the scope of the Cyber-TG Technical Subgroup for Information Sharing and Best Practices.

This routine nature of DoS/DDoS for service providers is also confirmed by the 2020 ICT Providers Survey from the Regional Center for Studies on the Development of the Information Society (Cetic.br), which indicated that 52% of companies with more than 45,000 accesses had suffered such an attack in the last 3 months. In regional terms, 30% of service providers in the Central-West region confirmed the occurrence[1]. Also, of the service providers that confirmed nationwide attacks, 10% reported that the attacks are constant, occurring every day, and 19% at least once a week.

Although service providers holding SMP demonstrate, through service availability and notifications to the Agency, that they possess robust capabilities to face this type of attack, Anatel is sensitive to the limited resources of the PPPs and has sought to develop actions to promote cybersecurity and resilience with this in mind. The Cybersecurity Guidance Guide for Telecommunications Service Providers – Basic Level, approved in September 2023, is a valuable tool to help PPPs develop their capabilities in this area. Anatel has interacted with representative associations of PPPs to disseminate this resource, organized a thematic dissemination event, and sent emails to PPPs. One of the biggest challenges is precisely the unique characteristics of the Brazilian connectivity ecosystem, which brings together almost 21,000 providers of fixed broadband internet access services[2].

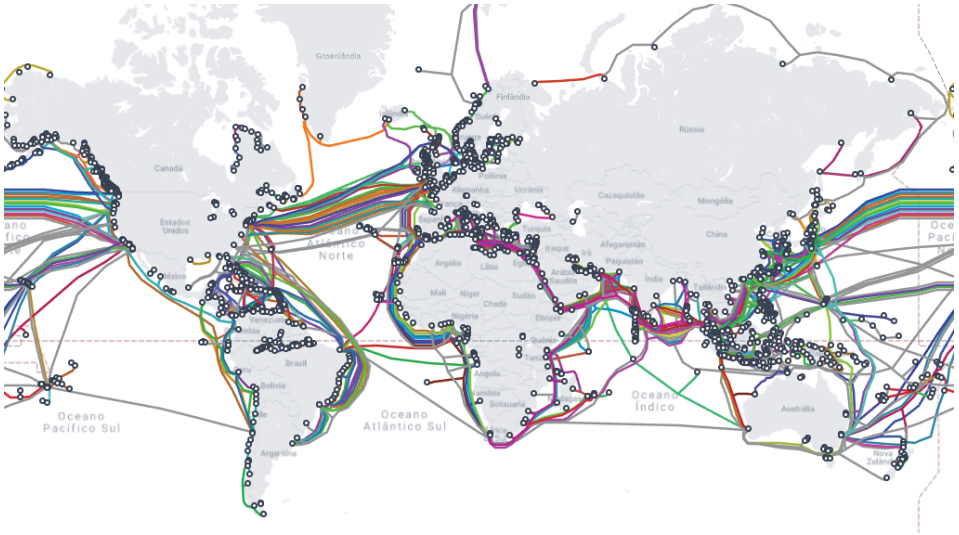
Regarding incidents, it is worth mentioning that, in compliance with Decree No. 10,748, of July 16, 2021, which establishes the Federal Network for Cyber Incident Management (FNCIM), Anatel approved a Sectoral Plan for Cyber Incident Management in August 2022 and established in 2023 a second Cyber Incident Prevention, Treatment and Response Team (ETIR), which has the fundamental role of sectoral coordination, that is, assisting the telecommunications sector in this process and centralizing incident notifications from the sector to forward to FNCIM.

Submarine Cable Security

The security of submarine cables is a fundamental element in guaranteeing the country's connectivity and its communication with the world. Several cables connect Brazil with different parts of the world, constituting an essential infrastructure for Brazilian telecommunications, responsible for more than 90% of the country's data transmission with other countries.

Different cables are anchored in different parts of the Brazilian coast, notably 17 submarine cables from eight companies are anchored at Praia do Futuro, in Fortaleza, Ceará. This cluster forms one of the main fiber optic cable hubs in the world. The figure below shows a map of submarine cables globally:

Figure 45: World map of submarine cables



Source: TeleGeography. Available at: https://www.submarinecablemap.com/.

It is undeniable that there is a need to guarantee the security of this CI, including from a physical security perspective. In this sense, Anatel is working on the subject from different perspectives.

Initially, service providers belonging to the Economic Groups of service providers holding SMP were required to adopt *ex ante* controls, that is, the obligations established in Cyber-R, in addition to basing their operation on the principles and guidelines contained in the Regulation. Also, with the Cyber-R update, all providers operating submarine cable(s) with international destinations must also adopt these controls.

The physical protection of these cables is no less important, given that the need to repair a submarine cable is a highly complex, costly, and time-consuming task. Therefore, prevention plays a crucial role. Specifically on this issue, Anatel strongly engaged with various other bodies and entities in opposing the construction of a desalination plant at Praia do Futuro, due to the risks to the 17

submarine cables anchored there, with the successful result of changing the originally proposed location[39].

Security in Data Centers

The ongoing digital transformation in the telecommunications sector relies heavily on a robust and resilient infrastructure. Data centers and cloud computing services play a fundamental role in this scenario, offering processing capacity, data storage, and security on an unprecedented scale.

According to Report No. 20/2024/COQL/SCO, data centers are strategic elements for meaningful connectivity, as they enable the effective management of complex networks, such as those supporting 5G technology. They are also critical for operations that require high availability and reliability, especially in the face of exponential growth in data consumption.

The report highlights that telecommunications providers in Brazil have adopted both their own data centers and cloud computing solutions provided by third parties. This hybrid strategy seeks to optimize operational efficiency and ensure flexibility in service expansion.

Regarding security, data centers need to meet rigorous standards for physical and cyber protection. Strategic location and connection redundancy are essential elements to ensure service continuity in adverse situations, such as natural disasters or cyberattacks. Also, advanced redundancy measures, such as N+1 and 2N architectures, become essential to mitigate the impact of critical failures.

Cybersecurity is a central concern in data center operations. With the evolution of threats such as ransomware and DDoS attacks, service providers must adopt a proactive approach, investing in solutions for continuous monitoring, intrusion detection, and rapid incident response. Tools based on artificial intelligence, for example, make it possible to predict and mitigate risks before they become critical.

The Report discusses measures such as network segmentation, data encryption at rest and in transit, and the use of next-generation firewalls. These practices are essential to minimize the risk of data breaches and protect critical infrastructure against cyber threats. Furthermore, compliance with national and international data security regulations, such as the GDPL (General Data Protection Law) and ISO standards, is mandatory. This ensures that operations are conducted with a high level of protection and respect for users' rights.

Figure 46 illustrates a correlation of the main security certifications adopted by data centers.

[39] https://www.gov.br/anatel/pt-br/assuntos/noticias/governo-do-estado-do-ceara-anuncia-a-realocacao-de-usina-de-dessalinizacao-em-fortaleza

Figure 46: Summary table of correlation between requirements and technical parameters among the main certifications

PARÂMETROS ENTRE AS REGRAS

UPTIME	ICREA	TIA-942	TUV
TIER I	NÍVEL I	RATED I	TR 1
Infraestrutura básica	Garantia de data center de qualidade (QADC)	Básico	Básico
TIER II	NÍVEL II	RATED II	TR 2
Componentes de capacidade redundante da infraestrutura	Garantia de qualidade de classe mundial (WCQA)	Componentes redundantes	Componentes redundantes
	NÍVEL III		
	Garantia de qualidade de classe mundial de segurança (S-WCQA)		
TIER III	NÍVEL IV	RATED III	TR 3
Redundância e manutenção concorrente	Garantia de qualidade de classe mundial de alta segurança (HS-WCQA)	Manutenção Concorrente	Sustentabilidade
TIER IV	NÍVEL V	RATED IV	TR 4
Infraestrutura tolerante a falhas	Garantia de qualidade de classe mundial de alta segurança e alta disponibilidade (HSHA-WCQA)	Tolerante a falhas	Tolerante a falhas
	NÍVEL VI		
	Rede de data center de garantia de qualidade de classe mundial alta redundante (RHA-WCQA)		
Desenho: Obrigatório **Construção:** Obrigatório	Desenho: (410.4.18) Não necessário **Construção:** Obrigatório	Desenho: Não requerido **Construção:** Obrigatório	Desenho: Obrigatório **Construção:** Obrigatório

Source: ZEITTEC

The growing reliance on cloud computing services brings new challenges, such as data sovereignty. The use of foreign cloud providers requires strict control over where data is stored and how it is managed, to protect user privacy and national security. To mitigate these risks, the suggestion is to implement policie to encourage the use of domestic data centers for storing sensitive information. This approach would strengthen the country's digital infrastructure and reduce its dependence on foreign services.

Anatel's role in overseeing these infrastructures is crucial. The Agency must monitor service providers' compliance with security standards, encourage the adoption of international certifications, and promote sustainable initiatives, such as the use of renewable energy sources and the optimization of operational efficiency. Integrating these measures with national cybersecurity guidelines will consolidate data centers as pillars of Brazil's critical infrastructure.

In terms of physical infrastructure, data centers must be designed to withstand failures and attacks. This includes redundant power supply systems, efficient cooling, and controlled physical access. The expansion of data centers must be aligned with sustainability goals. The telecommunications sector has been seeking solutions that minimize energy consumption and reduce its carbon footprint, such as adopting renewable sources and improving energy efficiency.

Green data centers, which use sustainable technologies, are a growing trend and are already showing promising results in reducing environmental impact. This approach is not only a corporate responsibility but also a necessity in the face of climate change.

Global connectivity depends on a robust network of submarine cables that interact directly with data centers to manage international data traffic. Ensuring the security and integrity of these interconnection points is vital for the stability of communications. It is important to highlight that service providers must adopt contingency plans for data center failure scenarios, with the goal of

ensuring the continuity of critical services. This includes data replication across multiple locations and disaster recovery strategies.

The growth of the Internet of Things (IoT) and artificial intelligence (AI) places an additional burden on data centers. These advancements demand an infrastructure capable of processing large volumes of data with low latency, something that modern data centers must be prepared to handle. Emerging technologies, such as edge computing, are transforming how data is managed. By distributing processing closer to end users, edge computing improves efficiency and reduces the load on central data centers. However, this decentralization also increases the complexity of cybersecurity, making each processing point a potential target for attack.

In short, data centers are pillars of modern digital infrastructure. Their security, efficiency, and resilience are fundamental to ensuring that Brazil can fully benefit from technological innovations while protecting its citizens and its digital sovereignty.

Vulnerabilities

Telecommunications networks and services are subject to vulnerabilities, which are a daily reality for telecommunications service providers, whether in their internal networks and systems or in the provision of telecommunications services. Although it is not possible to eliminate vulnerabilities, since new vulnerabilities are routinely discovered in code that can be exploited to carry out many different types of attacks on any organization, it is possible, through proper management, to mitigate them and minimize the chance of them being exploited.

With the expansion of connectivity, the increase in devices connected to the network, and the transformation of the network itself, especially with the deployment of fifth-generation (5G) mobile communication networks, the challenges of assessing and mitigating vulnerabilities are growing.

Cyber-R brings two related obligations. The first requires service providers subject to *ex ante* control to conduct vulnerability assessment cycles related to cybersecurity by a qualified and independent assessment entity or company, submitting the results to the Agency so that it has visibility over this process within this group of service providers.

The second obligation, which, following the revision of Cyber-R, applies to all Telecommunications Service Providers of Collective Interest, addresses a well-known and exploited vulnerability related to the default authentication configuration of Devices provided on loan to consumers. The goal is to prevent the installation and maintenance on the network of Devices with default login and passwords used to access Devices settings and the wireless network, and which are identical across multiple units or have an easily identifiable construction pattern.

In terms of monitoring the second obligation, Anatel has set a deadline for submitting a compliance plan regarding Devices already installed or in stock, and regularly receives reports on this progress from service providers holding PMS, which demonstrates a substantial reduction in the number of network-installed Devices with this vulnerability. In addition, mindful of the implications of emerging technologies for the cybersecurity and resilience of telecommunications networks and services, the Agency signed a Decentralized Implementation Agreement (DIA) with the Federal University of Campina Grande (FUCG) with a term of 20 months and the overall objective of

conducting technological, economic, regulatory, and standardization analyses related to cybersecurity in fifth-generation (5G) mobile communications systems, also covering legacy networks.

Much of the research focuses on the vulnerabilities related to the set of technological innovations in the context of 5G, and this valuable contribution allows the telecommunications sector to appropriate and internalize the knowledge considering the 5G deployment process in the country. The research was delivered to the Agency, shared and discussed with the service providers that operate 5G, and the results, materialized in scientific articles, are available on Anatel's page dedicated to cybersecurity.

TV Boxes and the Risks to Cybersecurity

The Inspection Superintendency – INS was a pioneer in the study on the use of non-approved TV Boxes and the risk to the cybersecurity of telecommunications networks. In 2021, it established a Working Group to conduct reverse engineering studies on TV boxes and cable TV or video-on-demand signal decoders, with the aim of proposing subsidies for the organization of the execution of inspections on the subject, under the terms of Anatel Ordinance No. 1972, of May 20, 2021 (EIS No. 6920053).

The aforementioned group concluded its work in 2022 with the preparation of a Technical Report (EIS nº 9409070 and 9580113) with the following results:

- The Android system of the analyzed TV Box devices lacks basic security mechanisms;
- The app stores used by the analyzed TV Box devices are not subject to the global security and control policies necessary for safety;
- The applications frequently used by the analyzed TV Box devices have been flagged as containing malicious files; and
- The update traffic for the applications used by the analyzed TV Box devices does not employ sufficient encryption for security.

Security flaws were detected in the application update process through proprietary virtual stores, allowing all exchanged information to be captured and modified by a malicious attacker, enabling the installation of malicious applications on the device. This vulnerability, coupled with another where the operating system of the devices allows third parties to have unrestricted access to the device with administrator privileges (known as "root"), enabling total control of the TV Box device, including access to other devices sharing the same network, such as computers, televisions, routers, cell phones and webcams, capturing user data and information, such as financial records, passwords, files, photos, etc.

During the proof-of-concept execution, for example, it was shown that devices connected to the same network as the TV Box could be compromised. The technical team was able to remotely execute applications, take static screenshots, and view and record the user's screen in real time (screenshare), without the user being aware of it. Given these results, there is no doubt that the use of non-approved TV Boxes represents a danger to consumers, as it exposes data and information, in addition to jeopardizing the cybersecurity of telecommunications networks due to the possibility of enabling various types of cyberattacks and crimes.

The Inspection Superintendency – INS, taking advantage of the Action Plan to Combat Piracy – APCP, has intensified efforts to curb the sale and use of this type of Devices, with various inspection actions throughout the country. Thus, regarding TV Boxes, up to July 2025, the inspection managed to remove 1,512,404 devices from the market, with a total estimated value of R$ 353,201,665.89, according to the results panel available at the following link: https://informacoes.anatel.gov.br/paineis/fiscalizacao.

Another front in the fight against the use of these non-approved devices is the Action Plan to Combat the Use of Clandestine Decoders for the Conditional Access Service - SeAC, approved by Anatel Internal Resolution No. 189, of February 7, 2023 (EIS No. 9798755). Under the aforementioned plan, the Superintendence of Inspection - INS may issue a blocking order to redirect traffic related to the unauthorized provision of SeAC (commonly known as pay TV) and the use of uncertified Devices, in order to:

- Meet the technical requirement for the adequate provision of services;
- Avoid harm to users, as TV Box devices can cause security breaches;
- Target only the unauthorized use of the service or the unapproved device;
- Contribute to mitigating cybersecurity risks in telecommunications networks; and
- Combat illegal and anti-competitive business practices by preventing the provision of clandestine services.

In addition to helping dismantle illegal content distribution networks and protecting consumers from unsafe devices, by July 2025, the implementation of the aforementioned plan had yielded the following results:

- 1,860 IPs blocked;
- 30,258 IPs monitored;
- 2,050 domains blocked; and
- 6,779 URLs monitored.

The results are available at the following link: https://dados.anatel.gov.br/dados/sense/app/3b38fa89-fbee-45cb-8046-b188d111ebdc/sheet/UUgYR/state/analysis

The Alert “Badbox 2.0” Malware on Uncertified TV Boxes

On August 12, 2025, the National Telecommunications Agency - Anatel issued a warning about the cybersecurity risks associated with non-approved TV Boxes (ANATEL, 2025). A recent study by the Inspection Superintendency - INS identified the presence of malware, called "Bad Box 2.0," in several TV Box models. This malicious software can compromise user data and the security of telecommunications networks, transforming devices with the Android operating system into tools for criminal activities without the owner's knowledge.

In this particular case, the aforementioned malware can be pre-installed on the unauthorized device or infect the device during the installation of applications from unofficial sources. Once infected, this virus uses the home network to integrate into a "Bad Box 2.0 network," with

thousands of infected devices remotely controlled by criminals. Typically, this type of network is used for several illegal activities, such as ad fraud; credential theft; the creation of fake accounts; the distribution of malware; and distributed denial of service attacks (DDoS.

Laboratory studies conducted by INS confirmed the presence of active malware in models such as InXPlus and TouroBox, as well as connections to external servers and the misuse of user IP addresses for illicit activities. Data from the Shadowserver platform showed an alarming increase in infected devices in Brazil: from about 340,000 IP addresses in February 2025 to over 1.8 million in August.

To address the problem, Anatel established technical and safety requirements for the homologation of Smart TV Boxes (Act No. 9281/2023), reinforcing the importance of acquiring only certified devices.

The main recommendations are: use only TV Boxes approved by Anatel; avoid installing apps from untrusted sources; keep systems and firmware always updated; and monitor network traffic and turn off suspicious devices.

The study also indicated the challenges in combating this malware due to the illegal sale of these devices, their use in home networks with dynamic IPs, and legal limitations on actions within residences. Combating BADBOX 2.0 requires a joint effort between the State, the private sector, and society, aligned with the National Cybersecurity Strategy (Decree 12.753/2025).

Also, the work carried out by the Inspection Superintendency – INS was recognized as an innovative and successful practice by the National Council to Combat Piracy – NCCP and received awards at WSIS 2024 and the TV Box Hackathon.

- National Anti-Piracy Award, presented by the Ministry of Justice and Public Security, in recognition of the significant impact of Anatel's Anti-Piracy Laboratory, inaugurated in September 2023, on cracking down on the illegal trade of telecommunications products throughout 2024. The award ceremony took place at the first NCCP meeting in 2025.
- International Recognition: the Action Plan to Combat Pirated TV Boxes received an award from WSIS 2024 (World Summit on the Information Society), highlighting its global significance.
- Promoting Innovation: hosting the TV Box Hackathon to recognize technological and creative solutions for combating unauthorized devices.

Awareness campaigns about the risks to the consumer.

In July 2025, Anatel launched a national awareness campaign about the risks of piracy and the use of unapproved Devices. This action, part of the 2025-2026 Anti-Piracy Action Plan, aims to educate the public about the dangers of irregular products, such as uncertified cell phones, drones, and TV boxes.

The campaign launch was marked by the release of the first educational video, focused on the dangers of purchasing uncertified cell phones, available on YouTube (https://youtu.be/JiSuFeZ6h2g). The material explains that irregular devices, in addition to not complying with technical standards, can even overheat or explode due to low-quality components.

Finally, cybersecurity is one of the main structural challenges for telecommunications networks. TV Box type devices pose a significant threat to the secure use of networks, and therefore, combating illegal Devices should be among the priorities of the telecommunications sector.

Cybersecurity from the Perspective of Meaningful Connectivity

Alongside technological and process measures related to cyber governance, equally important are actions aimed at raising awareness among all subjects in the ecosystem, including consumers of telecommunications services, regarding cyber risks and the need to adopt safe behavior, which, in addition to contributing to their own security, also contributes to the security of the ecosystem as a whole.

As such, raising awareness is a key element that should guide the actions of Anatel and telecommunications service providers, who are in a unique position to educate their customers and help them adopt safer online behaviors.

Cyber-R explicitly outlines the following guidelines that must be observed by all individuals or legal entities directly or indirectly involved in the management or development of telecommunications networks and services: the dissemination of a cybersecurity culture; the pursuit of the secure use of networks and services; the pursuit of cooperation between different subjects; and respect for and promotion of fundamental rights and guarantees.

Also, Cyber-R establishes that the CSP must expressly include in its action plan measures for raising awareness and educating its users about aspects of Cybersecurity. Annually, service providers must report to Anatel on the implementation of CSP, informing about the actions taken to raise awareness and educate their users, including aspects such as scope, estimated audience reached, actions on social media, the provider's web page on the subject, email marketing, and any alignments with other ongoing campaigns.

The importance and priority of the topic can also be seen in the Agency's Strategic Plan for the period 2023-2027, whose Initiative 17 seeks to ensure the prevention of fraud in the digital ecosystem, having as a strategic process objective the promotion of awareness and digital security of users and other agents and, as expected results, the following: the reduction of digital scams/frauds; and the increase in users' confidence in technology.

In implementing the Strategic Plan, the 2023-2024 Tactical Management Plan sets Goal 10 as the execution of 40% of the "Strategic Project for Digital Literacy and Skills" by 2024, which

includes reducing digital scams/fraud and increasing user confidence in technology, among other aspects. The Plan also defines the “Strategic Project for Trust in the Digital Ecosystem”, which aims to promote reference structures in the fight against and prevention of fraud in the digital ecosystem and, as results, the following: the fight against fraud in the digital ecosystem; reference structures in the fight against and prevention of fraud in the digital ecosystem; and the promotion of the relevance of the topic among key stakeholders, with an execution period of 60 months.

The Agency has been developing initiatives with diverse approaches and materials to raise awareness throughout society. In this sense, Anatel promoted the educational campaign #ConexãoSegura (Safe Connection) and motivated the creation of the #FiqueEsperto (Stay Alert) Movement.

This movement began in October 2020, as part of a Regulatory Oversight action by Anatel. Initially, a six-month campaign was conducted to inform and warn consumers about fraud in the digital environment. After this period ended, the Agency understood that, due to the relevance of the subject, the initiative should be continued.

Thus, the definition of a Movement emerged, through which periodic campaigns are carried out. One of the strengths of this movement is the gathering of diverse subjects from different sectors.

However, these efforts are insufficient to meet the challenges of raising awareness among a population of over 214 million people, including different social groups. In this context, the Agency organized the #OutubroCiberseguro (Cyber Security October) Initiative in 2023, an idea that became part of the Agency's permanent calendar, in order to carry out intensive actions with events broadcast on the Agency's official networks, the launch of dedicated pages, social media posts, and video releases. The choice of October is related to its recognition, in many countries, as a month for raising awareness about cybersecurity. When discussing awareness of cyber risks, we must not overlook the need to protect children and adolescents in this environment. Undoubtedly, the digital environment is one that children and adolescents should explore so that they can take full advantage of the potential these technologies offer, which can positively impact their lives in a wide variety of ways: education, information, communication, entertainment, and so on.

However, this environment presents some new and amplified old risks to which children and adolescents are exposed. Recognizing the absolute necessity of action from all subjects on this issue, Anatel mobilized resources and partners for the translation and layout of a set of guides with guidelines for policymakers; industry; and parents and guardians, as well as classroom materials for teachers and students and a children's book. These guides were produced by the International Telecommunication Union (ITU) and translated and formatted into Portuguese through a partnership between Anatel, the British Embassy, and the Brazilian Internet Steering Committee (CGI.br). All of these materials are available on the Agency's digital skills pages.

Just as good personal hygiene habits can greatly contribute to the health of the general population and save lives (washing hands, brushing teeth, etc.), good cyber hygiene habits can greatly contribute to security in the digital environment, preventing incidents from occurring or, if they do occur, mitigating their effects and damage.

In addition to raising public awareness about cybersecurity measures, the Agency is also focusing specifically on raising awareness about fraud in the digital ecosystem. Consequently, in October 2023, it launched a dedicated page on its website to discuss fraud prevention and provide security tips, as an additional awareness-raising initiative focused on the types of fraud most frequently reported to the Agency through its official customer service channels and social media platforms.

[1] Research on the Internet service provider sector in Brazil - ICT Providers 2020. Available at: https://cetic.br/pt/tics/provedores/2020/geral/G2A/expandido. Accessed on: September 29, 2023.

[2] Anatel Data Panels, Available at: https://informacoes.anatel.gov.br/paineis/outorga-e- licenciamento/panorama. Accessed on: September 29, 2023.

8. Anatel initiatives to expand the connectivity of specific groups

Accessibility

Considering accessibility as a fundamental right guaranteed especially through the Convention on the Rights of Persons with Disabilities and the Statute of Persons with Disabilities - Law No. 13.146/2015, Anatel has issued rules and guidelines for the telecommunications sector with the aim of enabling people with disabilities to enjoy services independently, in all aspects, by eliminating barriers to communication and information. According to the 2022 PNAD survey, among the 203 million Brazilians, 18.6 million people aged 2 years or older in the country had some type of disability.

In 1998, Anatel monitored the implementation of the General Universalization Goals Plan - PGMU (Decree 2,592/1998), which required Fixed Switched Telephone Service - STFC providers to offer a Communication Intermediation Center – CIC to people with hearing impairments. The following PGMUs (Decrees No. 4,769/2003, 7,512/2011, 9,619/2018, 10,610/2021) maintained the rule of the CIC obligation and added others. In 2005, Anatel published Resolution No. 426/2005, which established the duty of STFC concessionaires to provide accessible and priority services to people with disabilities. Subsequently, in 2007, Resolution No. 477 required Personal Mobile Service - SMP providers (mobile phone operators) to also offer CIC, as well as alternative plans for people with hearing impairments. Subsequently, in 2008, Resolution No. 509 was published, approving the CIC Regulation to be used by people with hearing or speech disabilities – CIC via text message. In 2014, Resolution No. 632 (General Consumer Regulation - GCR) established that providers of all services should provide accessible in-person and remote service.

With the advent of the Statute of Persons with Disabilities, and considering the studies and consultations carried out, Anatel approved the General Accessibility Regulation - GAR, through Resolution No. 667/2016. Besides consolidating existing regulatory standards from other Anatel Resolutions, the GAR introduced new obligations for telecommunications service providers, such as the Communication Intermediation Center – CIC via video and messaging.

And, in order to observe the principles of transparency, legality, and publicity of public administration, Anatel created tools to allow external oversight of accessibility in telecommunications services. In this sense, the Accessibility Ranking was created to assist in evaluating the effectiveness of the GAR and to make public the accessibility assessment of the main service providers. The Accessibility Ranking is a responsive regulatory tool, which consists of a comparative classification between service providers, according to the accessibility actions they promote.

Inspections carried out by Anatel in several Brazilian states verify the following indicators for the Ranking: Website Accessibility (API); Store Accessibility (ASA); and Remote Service Accessibility (ERA). Voluntary Actions that encourage/promote/ensure the rights of people with disabilities (AVI) are also considered.

The items verified, relating to each indicator, are listed in the Technical-Operational Manual of Implementation Procedures for the General Accessibility Regulation (MOGAR). Since 2019, the Accessibility Ranking has been published annually. The five largest providers are subject to inspection: Claro, Oi, SKY, VIVO, and TIM. Starting in 2025, the Accessibility Ranking will also evaluate small-scale providers based on their initiatives aimed at People with Disabilities.

The winning providers in the Accessibility Ranking were TIM (2019, 2021 and 2024), Claro (2020, 2022 and 2023) and Vivo (2025). It was observed that the winning service providers invested more in improvements to their websites and in services for People with Disabilities, especially in the CIC. Also, their stores have more adaptations such as tactile flooring, reserved spaces for people with motor disabilities, access ramps, among others. It should be noted that, over the years, all the providers involved in the Ranking have improved their indicators, so they are significantly better prepared to provide telecommunications services to people with disabilities.

In addition to promoting the inclusion of people with disabilities, Anatel is currently exploring ways to include other vulnerable social groups, such as those registered in the Unified Registry, indigenous people, women, the elderly, Black people, and illiterate individuals. Initial studies of ITU Resolutions[40] and international benchmarks already point to some instruments that can facilitate meaningful connectivity for these groups, such as digital literacy, simplicity of language in service delivery, offering more accessible service packages, assistive technologies, emergency services that consider the specific needs of people with disabilities, the elderly and illiterate people, and considering gender and race perspectives in the provision of public services. The goal is for access to telecommunications services, as a fundamental right, to enable all citizens to enjoy telecommunications services and Devices independently, in all aspects, by eliminating barriers to communication and information.

GAPE

The Auction Notice No. 1/2021-SOR/SPR/CD-Anatel, known as the 5G Notice, established that the winners of Lots G1 to G10, H1 to H42, I1 to I10 and J1 to J42, referring to the radio frequency sub-bands from 24.3 GHz to 27.5 GHz, should fulfill a commitment to connectivity in public basic education schools, with the quality and speed necessary for the pedagogical use of ICTs in educational activities regulated by the Connected Education Innovation Program, established by Law No. 14,180, of July 1, 2021, and by Decree No. 9,204, of November 23, 2017. Of the total value of the Auction, R$ 3.1 billion, originating from the 26 GHz band, was earmarked for this commitment.

In order to guarantee the coordinated execution of the projects, the 5G Call for Proposals also provided for the establishment of the Monitoring Group for the Cost of School Connectivity Projects (Gape), composed of representatives from Anatel, the Ministry of Communications, the Ministry of Education, and each of the winning bidders for the 26 GHz band.

[40] RESOLUTION 11 (Rev. Kigali, 2022) Telecommunication/information and communication technology services in rural, isolated and poorly served áreas (page 193).
RESOLUTION 34 (Rev. Kigali, 2022) The role of telecommunications/information and communication technology in disaster preparedness, early warning, rescue, mitigation, relief and response (page 262)
RESOLUTION 37 (Rev. Kigali, 2022) Bridging the digital divide (page 280)
RESOLUTION 46 (Rev. Kigali, 2022) Assistance to indigenous peoples and communities through information and communication Technologies (page 316)
RESOLUTION 55 (Rev. Kigali, 2022) Mainstreaming a gender perspective in ITU to enhance women's empowerment through telecommunications/ICTs (page 344)
RESOLUTION 58 (Rev. Kigali, 2022) Telecommunication/information and communication technology accessibility for persons with disabilities and persons with specific needs (page 355)
RESOLUTION 64 (Rev. Kigali, 2022) Protecting and supporting users/consumers of telecommunication/ information and communication technology services (page 381)
RESOLUTION 87 (Kigali, 2022) Connecting every school to the Internet and every young person to information and communication technology services (page 475)

With the goal of initiating practical connectivity experiences, in November 2022, Gape decided to develop a Pilot Project to serve 177 public basic education schools, located in 10 Brazilian municipalities, distributed among the five regions of the country: Pau D'Arco – PA (11 schools), Espigão do Oeste – RO (22 schools), Baía da Traição – PB (17 schools), Santa Luzia do Itanhy – SE (21 schools), Gaúcha do Norte – MT (15 schools), Cavalcante – GO (22 schools), Berilo – MG (23 schools), Silva Jardim – RJ (21 schools), Entre Rios – SC (10 schools) and Coronel Domingos Soares – PR (15 schools).

The municipalities were selected based on technical criteria developed by the group, taking into account variables such as the Municipal HDI, the number of students benefiting from the program, the size and connectivity of the municipality, and the presence of schools on indigenous lands, in remaining quilombo communities, and in rural settlements.

Following the guidelines approved by Anatel Ordinance No. 2347, of May 9, 2022, amended by Ordinance No. 2607, of April 14, 2023, all schools were equipped with complete connectivity infrastructure, including high-speed internet access (1 Mbps/student, considering the number of students enrolled in the longest shift and at least 50 Mbps per school), Wi-Fi network for distributing internet access in the school environment, and computers to be used by students and teachers.

The complete list of selected schools, including their characteristics, as well as that of all other basic education institutions in the Brazilian public school system, can be viewed on the School Connectivity Panel, available on the Anatel website.

On September 26, 2023, the Federal Government issued Decree No. 11,173, which established the National Connected Schools Strategy (Enec), with the purpose of coordinating actions to universalize quality connectivity for pedagogical and administrative use in public basic education schools. According to the aforementioned Decree, Enec aims to combine the efforts of bodies and entities of the Union, the States, the Federal District and the Municipalities, schools, the business sector and civil society to achieve the following objectives:

I - To promote universal connectivity for public basic education schools;

II - To promote equal opportunities for access to digital technologies in the teaching and learning process;

III - To contribute to digital learning and improved management by expanding access to the internet and digital technologies for students, teachers, and administrators in the public basic education network.

The Decree stipulated that the Enec would be implemented in coordination with other initiatives aimed at promoting the pedagogical use of digital technologies and integrating digital education into basic education. It also established for the Executive Committee of Enec the function of coordinating policies, plans, programs, initiatives, and the provision of resources related to the connectivity of educational establishments in the public basic education network.

The Enec determinations affect the next phases of Gape, and the projects of Phases 2, 3, and 4 have already incorporated the new criteria (Phases 2 and 3: 5,320 schools; Phase 4: 18,555 schools). The project's progress can be followed using the information available on the Anatel website.

Decree No. 2846, of August 5, 2024, established new guidelines for the development of Gape projects, to incorporate the Enec determinations into the projects of the new Gape phases. Phases 2, 3, and 4 of Gape, currently underway, have already incorporated the new criteria established by Enec.

On November 29, 2024, Decree No. 12,282 was issued, which provides for the competencies, within the scope of the federal public administration, related to commitments made from the allocation of resources resulting from auctions for authorization to use radio frequencies, and provides other measures.

Decree No. 12,282/2024 established the competence of the Ministry of Communications to define and regulate the attributions and governance structure applicable to commitments made from the contribution of resources by the winners of auctions for authorization to use radio frequencies, having established that its provisions would be applicable even to auctions for authorization to use radio frequencies already carried out.

Ministry of Communications Ordinance No. 15,371, of December 2, 2024, which altered the attributions and governance structure applicable to the commitments addressed in Annex IV-C of Auction Notice No. 1/2021-SOR/SPR/CD-ANATEL, establishing that the functions of president and executive secretary of Gape are now exercised by representatives of the Ministry of Communications.

Following the publication of MCOM Ordinance No. 15,371, of December 2, 2024, the governance structure applicable to the commitments addressed in Annex IV-C of the 5G Auction Notice became the responsibility of the Ministry of Communications. Monitoring of Gape's activities should be done on the Ministry of Communications website: GAPE — Ministry of Communications.

Brazilian Connectivity Index (BCI)

The Brazilian Connectivity Index (BCI) is an index developed and calculated by Anatel, which presents a ranking of Brazilian municipalities and states, comparing their connectivity levels. To do this, the BCI relies on data from the telecommunications sector measured, calculated, and collected by Anatel itself, as well as other Brazilian government agencies. The BCI is inspired by other national and international indicators, especially the ICT Development Index (IDI) of the International Telecommunication Union (ITU). The IDI has been published annually since 2009, and is composed of a combination of indicators in a benchmark measure. The indicator was developed in alignment with Anatel's results objectives, as outlined in its strategic plan to "promote the dissemination of sectoral data and information". The BCI is published on Anatel's data dashboard[41].

The goal of BCI is for it to be specifically applied to activities and studies in the telecommunications sector, but also to serve as a source of information in economic and social studies. Among the areas of application, the most direct is the possibility of ranking Brazilian municipalities and states in order to compare them in relation to their connectivity level, with the aim of creating an incentive structure that, through competition between locations, promotes a natural and organic development of the telecommunications sector in those municipalities and federative units that are most lagging behind.

41 NATIONAL TELECOMMUNICATIONS AGENCY (Brazil). Brazilian Connectivity Index. Available at: https://informacoes.anatel.gov.br/paineis/meu-municipio/indice-brasileiro-de-conectividade

Another possible application is to disseminate and spread best practices for increasing connectivity through the promotion of the BCI and the positive evolution of the index, since many locations that adopt best practices for expanding ICT may have such practices disseminated. It is also possible to present society with a higher level of information by sharing a structured set of organized and comparable data on the connectivity status of municipalities, federative units, and the country. The BCI calculation methodology was approved by the Anatel Board of Directors through Anatel Internal Resolution No. 231, of August 8, 2023, and is included in the Methodological Report[42].

The indicator is the result of the weighted average of seven variables. For the purpose of simplifying the index and comparing the variables that make up the BCI, these indicators were normalized on a scale of 0 to 100, where 0 represents the lowest score for the specific indicator and 100 represents those with the highest scores across the indicators.

Community Networks

As an alternative to traditional investment options, community networks offer the possibility of building access networks in regions with low financial returns, whether wireless or fiber optic, particularly in rural and isolated areas. They are managed collaboratively, developed in a bottom-up model by groups or individuals who conceive, develop, and manage the new common-good network infrastructure. According to the study The Community Network Manual: How to Build the Internet Yourself[43], these networks have important characteristics that favor sustainable development: social organization with shared objectives, cultural and educational balance, and governance definitions – with regulatory measures focused on supporting interconnection to the backhaul and backbone of companies already established in the market – and shared costs and benefits among the related communities.

In Brazil, community networks can operate following the guidelines of the regulations issued by Anatel regarding telecommunications services of restricted interest, especially the Private Limited Service (PLS), whose main regulation is approved by Resolution No. 617, of June 19, 2013.

In September 2020, a Memorandum of Understanding (MoU) was signed between Anatel and the British Embassy with the aim of expanding digital access in Brazil. The first result of this agreement was the production of studies[44] related to promoting Community Networks in Brazil. Based on the delivered products, especially the Policy Brief, Anatel can map potential needs for improvement in Anatel's regulation, in order to promote Community Networks in the country. The other products, namely the Community Networks Manual and the promotional videos, constitute a very useful tool for potential stakeholders to access objective and high-quality information for the expansion of community networks, directly contributing to increased digital access among the most vulnerable populations.

Subsequently, in March 2023, the Working Group for Studies on Community Networks – WG-ComN – was created by Anatel Ordinance No. 2597, of March 29, 2023, with the objective of

[42] NATIONAL TELECOMMUNICATIONS AGENCY (Brazil). Internal Resolution No. 231, of August 8, 2023. It approves the methodology for calculating the Brazilian Connectivity Index - BCI. Available at: https://informacoes.anatel.gov.br/legislacao/resolucoes-internas/1882-resolucao-interna-231

[43] https://bibliotecadigital.fgv.br/dspace/handle/10438/25696

[44] All studies and documents relating to the aforementioned Memorandum of Understanding are available in files no. 53500.018191/2020-43 and no. 53500.067823/2020-01.

promoting dialogue between the Agency and representatives of community networks, providing input for the debate on the reassessment of the rules applicable to these networks, as foreseen in item 5 of the 2023-2024 Regulatory Agenda. Meetings began in June 2023 and continue to be held periodically[45].

From the studies and debates that took place within the WG-ComN, four thematic axes essentially emerged regarding the topic: a) sustainability of the model and governance; b) technological appropriation and technical capacity building; c) regulatory environment and access to inputs; and d) public policies related to the use of the Fund for the Universalization of Telecommunication Services - FUTS.

Among the initiatives most recommended by representatives of community networks within the WG-ComN framework is the need to assess the possibility of using FUTS to stimulate the expansion of community networks, interacting with the Fund's Management Council to update the project portfolio as appropriate. Also, the need for Anatel to reassess its regulations to facilitate access to community networks in various ways, such as licensing, access to wholesale inputs, improvement of regulatory oversight, and other actions, stand out (carried out in process no. 53500.025962/2023-00).

[45] The full text of the documents relating to GT-RCOM is also available on Anatel's website, at https://www.gov.br/anatel/pt-br/composicao/grupos-de-trabalho/gt-rcom.

9. Project Design to Address Identified Gaps

Once the several dimensions that address the concept of universal and meaningful connectivity have been explored, several projects can be structured to encompass each of them and aim to bring the effectiveness of connectivity to Brazilian society. Since the concept is multifaceted, solutions for all facets of the issue are not sought within the PERT. The objective of this chapter, therefore, is to list the possibilities for structuring potential projects aimed at improving connectivity, mainly in matters related to infrastructure and quality. The remaining dimensions are addressed in several other projects within Anatel, according to its Strategic and Tactical Planning, and it is also worth mentioning the determination of the Board of Directors within the Ordinary Dispatch No. 12771295 for the construction of the Meaningful Connectivity and Socio-environmental Sustainability Plan (MCP).

In this sense, project structuring can be approached from the perspective of specific needs or from the perspective of the type of infrastructure that one aims to implement or expand. The following presents possibilities for projects that aim to encompass either of these perspectives.

Projects that involve the dimensions of infrastructure and quality.

Connectivity projects for locations of significant public interest

From the perspective of providing connectivity to meet specific needs, projects can be structured for a wide variety of sectors where the public interest is present. The following map aims to illustrate, in a non-exhaustive way, some possibilities that can be considered with both fixed and mobile access network infrastructures, depending on the level of synergy between the type of infrastructure and the present need:

1. Educational Connectivity:

Educational connectivity projects can focus on providing the necessary infrastructure to connect the school environment so that such connectivity can be used pedagogically. In line with NCSS criteria, projects of this nature must adopt the minimum parameters established by the Strategy, seeking to bring connectivity to those educational establishments lacking such infrastructure or to improve connectivity in those where the existing infrastructure does not meet the established parameters. Connectivity should include internet access with adequate quality for educational purposes and a wireless network to distribute the signal to all school environments.

2. Telehealth in Primary Health Care Units:

Similarly to educational connectivity, projects linked to the healthcare environment may be associated with the need to implement the necessary connectivity infrastructure in Basic Health Units (BHU) and Health Posts, aligning with the telehealth policies of the Unified Health System (SUS, in Portuguese).

Accurate mapping of health units and coordination by the Ministry of Health regarding prioritization and service strategies for these units is essential for the success of projects of this nature.

3. Connected Rural Development:

The rural environment presents one of the major connectivity challenges for Brazil, considering its vast, continent-sized territory. Projects in rural areas can focus on expanding coverage

in general, or they can have more specific objectives such as promoting connectivity in rural settlements, focusing on family farming, quilombola communities, and other traditional communities.

Unlike the structuring of projects focused on expanding mobile infrastructure in general, as mentioned in the following chapter, here the focus is on specific areas. Again, the correct mapping of these areas proves essential for the success of the project.

4. Tourism and Connectivity:

In the tourism sector, it is also possible to structure projects aimed at expanding coverage and connectivity in areas of tourist interest in the country. An initial diagnosis has already been presented in previous chapters that highlight the different tourist regions of Brazil and their distribution across the states. Again, the Ministry of Tourism's role in coordinating the survey and prioritization criteria for different Brazilian tourist areas is essential to the effectiveness of projects of this nature.

5. Strengthening Community Networks:

As already pointed out in previous chapters, community networks are an alternative to traditional investment options, offering the possibility of building access networks in regions with low financial returns, particularly in rural and isolated areas.

This community-driven nature sets them apart from traditional infrastructure expansion, as they directly involve community participation in the design, implementation, and maintenance of the connectivity that serves them. In this regard, projects aimed at facilitating the implementation of this type of network are of great interest and should be structured in a tailored manner, since each region of the country and each individual community will have specific needs that must be addressed.

The projects must include, among other things, an internet connection link, Devices for distributing the signal (fixed or mobile) among the community, terminal Devices for users, network maintenance, and training.

6. Underground infrastructure for mobile communication:

Generally, the focus of connectivity implementation, especially mobile networks, is on outdoor environments, although network structuring allows for indoor connectivity in many situations. However, there are public spaces that have difficulty using the connectivity already present in outdoor environments due to their specific characteristics. Examples of such public spaces are subways and road tunnels.

Such environments can offer important opportunities for evaluating connectivity strategies, considering the large flow of people in these urban infrastructures. Projects that seek to bring meaningful connectivity to these spaces should be considered. However, they require a specific diagnosis for their structuring, given the unique characteristics of each public space.

Projects to improve the quality of 4G/5G mobile coverage (SMP)

1. Improving 4G/5G coverage in areas with low levels of social development

It is known that the coverage provided by mobile operators can be heterogeneous across different regions of the same municipality, with regard to its quality parameters, such as download and upload data transmission rates. This heterogeneity can be even more pronounced in areas of low economic and social development.

These areas are designated by the IBGE as Subnormal Agglomerations and are defined[46] as forms of "irregular occupation of land owned by others – public or private – for housing purposes in urban areas and, in general, characterized by an irregular urban pattern, lack of essential public services and location in areas restricted to occupation". In Brazil, these irregular settlements are known by several names such as favelas, invasions, ravines, lowlands, communities, villages, backwaters, irregular subdivisions, shacks, and stilt houses, among others. It is further added to the definition that, "in these areas, populations generally reside with more precarious socioeconomic, sanitation, and housing conditions".

IBGE carried out a georeferenced survey of the urban polygons corresponding to the Subnormal Agglomerations throughout the country, identifying them in 734 municipalities in all States and the Federal District, totaling 5,127,747 households.

It is considered that the use of identification data for Subnormal Agglomerations by the IBGE, associated with studies carried out by Anatel that aim to identify areas with low levels of coverage quality, can result in projects to increase the Base Transceiver Stations (BTSs) in areas of low social development, in order to ensure the improvement of the quality of service made available to the population.

2. Expansion of 4G/5G coverage in locations of significant public interest

Anatel is frequently asked by states, municipalities, and federal agencies to intervene with mobile service providers to implement projects aimed at expanding mobile coverage in areas considered to be of strategic interest, such as military bases, research and development areas, and industrial and technological hubs, which are sometimes located far from urban areas within municipalities, and therefore lacking significant mobile coverage, as operators are not required to install infrastructure in these regions.

It is considered that such demands can be adequately framed as the object of a public policy for expanding mobile coverage, considering the relevance of the activities that are developed in the areas in question, and the knowledge that Anatel already has of the location of these areas, resulting from the numerous demands it receives.

Projects to expand mobile coverage can also be linked to projects under development in other areas of the federal government, such as the Ministry of Health, which may require the installation of mobile infrastructure in remote regions of the country to provide connectivity in advanced health posts.

3. Expansion of 4G/5G coverage in rural areas, federal and state highways, and locations and municipalities that do not have this coverage

Other points of attention regarding the needs for expanding the mobile network are the traditional projects to serve municipalities, towns, highways and rural areas, which the Agency has been encouraging over the years through its own regulatory acts such as TACs, Obligations to Do - OTP and Auction Notices.

[46] https://www.ibge.gov.br/geociencias/organizacao-do-territorio/tipologias-do-territorio/15788-aglomerados-subnormais.html?=&t=sobre

Anatel has data panels with relevant information on these gaps and should continue to improve the mapping to ensure that the entire population can be served by mobile networks with the best possible quality.

4. Expansion of 4G/5G network capacity

It is considered extremely important to expand the capacity of 4G/5G mobile networks by increasing the Base Transceiver Stations (BTSs) and expanding capacity in municipalities and locations in general, not just in subnormal agglomerations. The increase in the number of BTSs aims to meet the growing demand for data services and ensure that the quality of the mobile connection is maintained, even in the face of an increase in the number of users and connected devices. This expansion is fundamental to providing more robust and homogeneous coverage, reducing dead zones and improving download and upload data transmission rates. Also, it is necessary to strategically plan the densification of BTSs to optimize spectrum use and ensure efficient service delivery, serving both dense urban areas and more remote locations that demand greater coverage and capacity.

Projects for the Expansion and Increase of the Capacity of Transportation Networks

1. Backbone Infrastructure Improvement: focus on expanding and improving backbone networks that connect different regions of the country. This includes installing new fiber optic cables, including for redundancy, upgrading Devices to support higher data traffic, and integrating newer technologies to improve network efficiency.

2. Regional and International Interconnection: development of projects to improve interconnection between regions and with international networks, aiming to increase network resilience and reduce latency, especially in border areas and remote regions.

3. Expansion of Transportation Networks in Rural and Remote Areas: projects focused on expanding the transportation network (backhaul) to rural and remote areas, improving connectivity for isolated communities and promoting digital inclusion.

4. Technological Upgrade to Support New Generations of Mobile Networks: preparations of transport networks to support the demands of future generations of mobile networks, such as 5G and beyond, including the installation of compatible Devices and the upgrading of existing networks.

Fixed Access Network Expansion Projects

1. Expanding Fiber Optic Coverage: initiatives to expand fiber optic coverage to the home (FTTH - Fiber to the Home and FTTP - Fiber to the Premises) or to the cabinet (FTTC - Fiber to the Cabinet), providing greater speed and connection quality.

2. Modernization of Legacy Networks: transformation of legacy networks, such as copper networks, to support newer technologies (e.g., high-speed DSL), aiming to improve service quality in areas where fiber optic installation is not feasible.

3. Use of new technologies in access networks, such as FWA (Fixed Wireless Access): the use of wireless technologies, especially FWA, based on 5th Generation networks, can be an important alternative in the expansion of fixed broadband.

4. Connectivity in Underserved Urban Areas: focusing on the development of fixed broadband network infrastructure in urban areas that still suffer from lack of access or poor quality connections, including peripheral neighborhoods and subnormal agglomerations.

5. Public-Private Partnerships for Network Expansion: encouraging the formation of public-private partnerships for the expansion of fixed access networks, leveraging resources and expertise from both sectors to accelerate infrastructure deployment.

Infrastructure Projects: Data Centers and Submarine Cables

1. Expansion of the national capacity of data centers, encouraging investments in strategic regions to decentralize digital services.

2. Development of new submarine cables to strengthen international connectivity and reduce telecommunications operating costs in Brazil.

Projects that involve the other dimensions of Universal and Meaningful Connectivity

Projects for the Promotion of Digital Skills

1. Actions to promote intermediate digital skills, with a primary focus on young people aged 16 and over from the outskirts of large urban centers and municipalities with lower income and education levels, regardless of race or ethnicity.

2. Reduction of digital skills inequalities as outlined below:

I. Basic Skills: female gender, social classes D and E, Northeast region, elderly, rural and indigenous areas;

II. Intermediate Skills: female gender, social classes C, D, and E, Northeast and North regions, completed primary education, economically active, rural areas, and Asian population;

III. Advanced Skills: female gender, social classes C, D, and E, Northeast and South regions, completed secondary education, economically active, rural areas, and Black population.

Projects for Price Reduction and Improved Accessibility

1. Development of partnerships with manufacturers to offer devices at reduced prices in markets with low economic attractiveness.

2. Implementation of direct subsidies or tax incentives for mobile devices and fixed broadband Devices.

3. Creation of platforms for monitoring and comparing prices of services and devices in different regions, promoting transparency and competitiveness.

Projects for the Improvement of Network Security

1. Establishment of advanced security protocols to protect critical networks against cyberattacks.

2. Implementation of continuous monitoring systems for real-time threat identification and mitigation.

3. Partnerships with research institutions to develop security solutions based on artificial intelligence.

Projects for the Promotion of the Safe Use of Networks

1. Educational campaigns about good practices in internet use, focusing on children, teenagers, and the elderly.

2. Launch of interactive platforms that guide users on how to avoid online scams, fraud, and threats.

3. Creation of a hotline for reporting cybercrimes in collaboration with other government entities.

Projects for the Acquisition of High-End Devices

1. Implementation of collective purchasing programs to reduce costs when buying high-performance Devices, such as routers and servers.

2. Incentives for the nationalization of components and technologies, reducing dependence on imports.

3. Creation of lines of credit for regional providers to acquire high-end Devices, promoting a level playing field.

Projects for Sustainability in the Telecommunications Sector

1. Promotion of sustainable practices in infrastructure deployment, including the use of recyclable materials and the reduction of environmental impacts.

2. Encouraging the adoption of green technologies, such as networks powered by renewable energy.

3. Partnerships with service providers to develop carbon neutrality projects, aligned with global best practices.

10. Conclusion: Consolidating the Path to Meaningful Connectivity

As we conclude the review of Anatel's Telecommunications Network Structural Plan (PERT), it is essential to reflect on the significant progress made and the challenges that remain on the path towards universal and meaningful connectivity in Brazil. This Plan, in its essence, is a vital strategic roadmap to guide the Agency through the complex and dynamic world of telecommunications, towards a future in which every citizen has access to information and communication in an equitable and effective manner.

Significant Progress

Infrastructure Expansion: we have witnessed a remarkable expansion of telecommunications infrastructure, especially with the implementation of 4G networks and the beginning of 5G deployment. This expansion not only improves the quality of connectivity in urban areas but also extends the reach of networks in rural and remote regions.

Digital Inclusion: through several initiatives, including targeted policies and public-private partnerships, access to the Internet and digital technologies has become more accessible, reducing the digital divide and promoting inclusion at all levels of society.

Improved Service Quality: the quality of telecommunications services has improved considerably, with higher speeds and better coverage, contributing to a more satisfactory user experience.

Persistent Challenges

Inequality in Accessibility: despite progress, there is still a significant disparity in the accessibility of telecommunications services, especially between urban and rural areas, and between different socioeconomic strata.

Technological Updates: the fast evolution of telecommunications technologies demands constant updates to infrastructure and services, a significant logistical and financial challenge.

Sustainability and Environmental Impact: as telecommunications infrastructure expands, environmental impact must also be considered, and work must be done towards more sustainable solutions.

Path to Follow

In order to achieve the overall goal of universal and meaningful connectivity, it is imperative that work continues on several fronts:

Focus on Inclusion and Accessibility: it must be ensured that telecommunications expansion and improvement projects consider the needs of all communities, especially those in remote and socially disadvantaged areas.

Adoption of Emerging Technologies: promoting and integrating new technologies, such as the Internet of Things (IoT) and artificial intelligence (AI), the 6th generation of wireless communications

and machine learning (ML), is essential to keep Brazil at the forefront of innovation in telecommunications.

Public Policies and Regulation: up-to-date policies and regulations are crucial to guiding the development of telecommunications infrastructure and services, ensuring that the benefits of connectivity are widely distributed and accessible.

Strategic Partnerships and Investments: encouraging partnerships between the government, the private sector, and international organizations to mobilize the resources needed for the expansion and maintenance of a robust telecommunications infrastructure.

Commitment to Sustainability: incorporating sustainable practices into the development and expansion of telecommunications networks is vital to protecting our environment and ensuring the long-term viability of telecommunications initiatives.

Conclusion

The PERT, as a living document that is constantly evolving, reflects Anatel's commitment to Brazil and to a connected and inclusive future. Recognizing the progress we have made and addressing the challenges that remain, we are charting a promising course to ensure that every Brazilian has access to quality telecommunications services, regardless of their location or socioeconomic status. This path, while fraught with challenges, is full of opportunities to shape a more connected, informed, and inclusive society.