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WIND AND SOLAR ENERGY IN BRAZIL

FLANDERS INVESTMENT & TRADE MARKET SURVEY



WIND AND SOLAR ENERGY IN BRAZIL

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CONTENT

1.	Renewable energies in Brazil.....	3
2.	Growing power demand.....	5
2.1	Demand for continuous energy growth.....	6
2.2	Carbon zero direction.....	7
3.	Wind power in Brazil.....	8
3.1	Financial support – The BNDES role.....	11
3.2	Wind Energy Installed Capacity.....	12
3.2.1	New installed capacity – Wind energy.....	13
3.2.2	Top 10 cumulative capacity in the world – Wind energy.....	13
3.3	Investments in new wind projects in Brazil.....	14
3.4	Wind power supply records.....	14
3.5	The superb quality of the winds of Brazil.....	15
3.6	Brazilian states with higher wind energy generation.....	16
3.7	Wind power contribution to residential supply.....	17
3.8	Advantages of wind power installations in Brazil.....	18
3.9	Wind installations support local communities.....	19
3.10	Energy auctions and free market sales.....	20
4.	Offshore wind energy in Brazil.....	21
4.1	Offshore wind projects.....	22
5.	Green hydrogen: near future for Brazil.....	25
6.	Solar energy in Brazil.....	27
6.1	The solar sector in Brazil in a nutshell.....	28
6.2	Brazil’s high levels of insolation.....	29
6.3	Installed capacity.....	30
6.4	Distributed generation by states and major cities.....	31
6.5	Distributed generation by consumer types.....	32
6.6	Centralized generation by 10 major producing states in Brazil.....	33
6.7	National PV solar manufacturers.....	34
6.8	Electricity generation records.....	35
6.9	Solar PV competitive prices.....	36
7.	Free and regulated energy market.....	37
8.	Challenges and opportunities.....	39
9.	Most important associations.....	41
9.1	Wind power (onshore and offshore).....	41
9.2	Solar energy.....	41
10.	Most important fairs.....	42



1. RENEWABLE ENERGIES IN BRAZIL

As the Brazilian energy market professionals like to say, while most of the countries in the world need to manage the scarcity of renewable energy in their energy matrices, Brazil needs to manage the abundance.

According to the last National Energy Balance report (BEN, 2022), the share of renewables in the Brazilian energy matrix was 44.7% in 2021, much higher than that observed in the rest of the world.¹

If we only focus on the generation of electricity, the share of renewables in the Brazilian electricity matrix stood at 81,2% at the end of 2022: 51,8% hydropower with 190.770 MW generation, 11% wind energy with 23.268 MW generation, 10,6% solar PV with 22.357 MW generation and 8,6% biomass + biogas with 16.618 MW generation. All of that makes that Brazil has one of the cleanest electricity matrixes in the world.

Additionally, onshore wind generation only reached 23.26 MW and solar generation reached 22.35 MW!

And we are not talking here about biofuels, biogas, biomethane, etc. Brazil did not ignore the potential of its natural resources, and has been investing heavily in energy sources diversification, with good results. So, we could not simply disregard the amazing potential of the offshore wind power in Brazil.

The country is blessed with a huge coastline of 7,367 km and great winds, and finally, government and private sector are aiming to develop solar photovoltaic, onshore, offshore wind business and green hydrogen in the near future.

The high interest of many international companies on what is going on in Brazil is notorious, and it is difficult for any professional, located overseas, to get an overall idea about the moment of the market in the country.

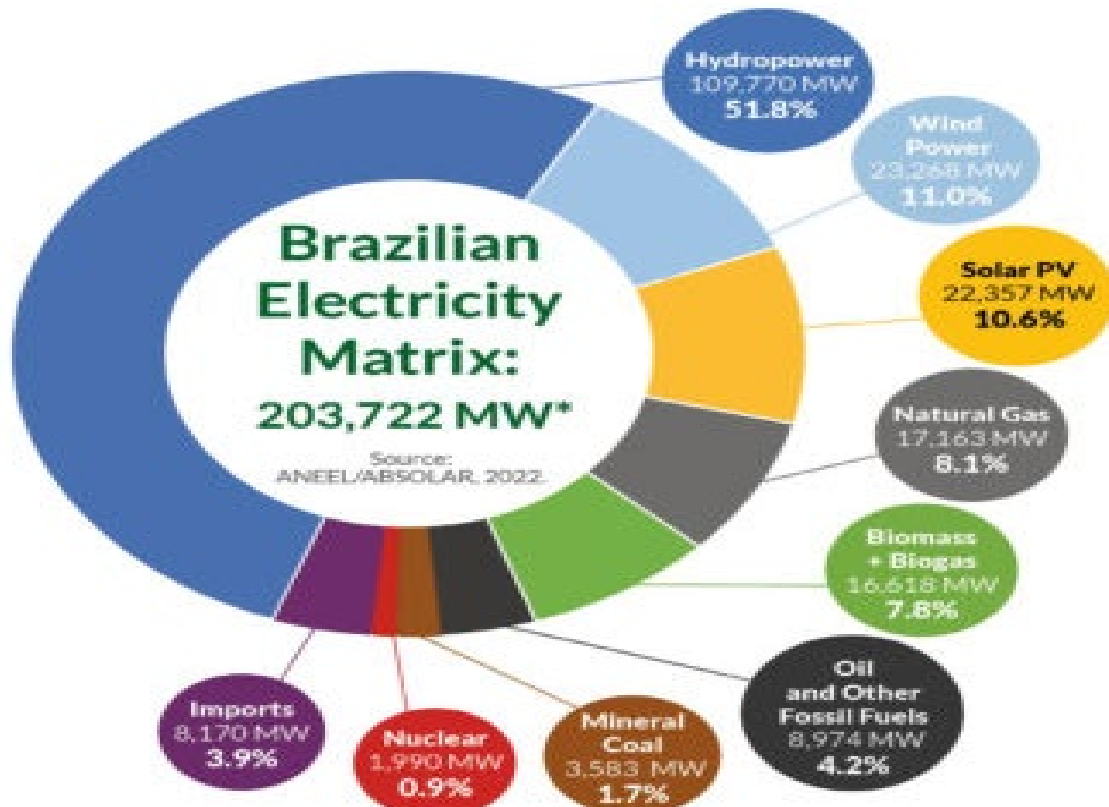
With that in mind, we decided to prepare this report, that presents a broad overview of what is happening in Brazil regarding the development of mainly the solar photovoltaic and the onshore and offshore wind market.

¹ <https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-675/topico-638/BEN2022.pdf>



Evolution of the Brazilian electricity matrix

The chart below shows the percentage contribution from all sources of energy to the electric power grid at the end of 2022. ² Wind power makes up 11% of the nation's power matrix. In 2021 wind power was the fastest growing source: a total of 3.83 GW of wind capacity was added to the Brazilian energy matrix. The second fastest growing source was solar PV, now responsible for 10.6% of new capacity.



¹ The matrix total capacity does not include imports. In addition, mini and micro distributed generation are considered in the values of installed capacity for each source, according to criteria applied by MME.

** The matrix total capacity does not include imports. In addition, mini and micro distributed generation are considered in the values of installed capacity for each source, according to criteria of MME – Brazilian Ministry of Mines and Energy (2022).*

² <https://www.portalsolar.com.br/noticias/operacao-e-expansao/oem/solar-e-terceira-fonte-com-maior-participacao-na-matriz-eletrica-brasileira>



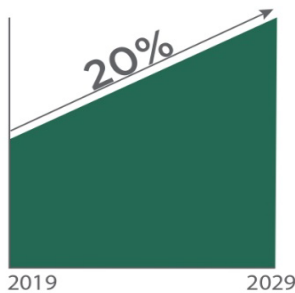
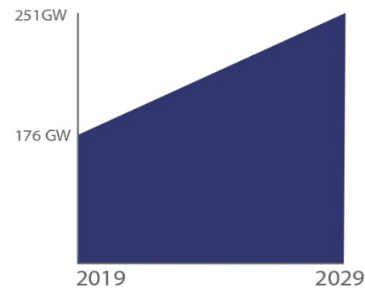
2. GROWING POWER DEMAND

Brazil's power demand will grow by 20% from 2019 to 2029: from 176 GW total installed capacity in 2019 to over 250 GW installed capacity in 2029. Solar photovoltaic is expected to surpass wind energy already by the beginning of 2023, especially with solar panels installed over roofs and ceilings (93% of solar PV installations)

Brazil attracted more than USD 20 billion in new asset finance for clean energy plants from 2009-2018, by far the largest amount in Latin America over that period!

Forecast – a continuous growth

The National Energy's Plan 2029 (PDE 2029) forecasts that **Brazil's installed capacity will grow** from 176 GW, in 2019, to 251 GW, in 2029.



The country's **power demand will grow over 20% until 2029**. By 2050, it is estimated that Brazil will need USD billion in investments for renewables.

According to PDE 2029, Brazilian National Energy Plan 2029 ³

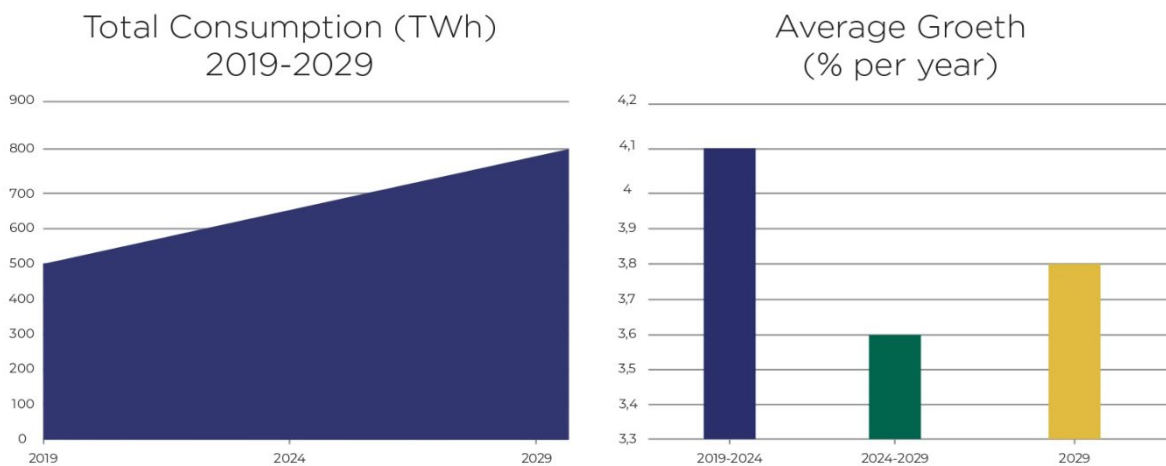
³ <https://www.epe.gov.br/en/publications/publications/pde-2029-executive-summary>



2.1 DEMAND FOR CONTINUOUS ENERGY GROWTH

The increase in installed capacity is essential to meet the continuous growth of the Brazilian energy demand.

Projected increase in energy demand by 2029



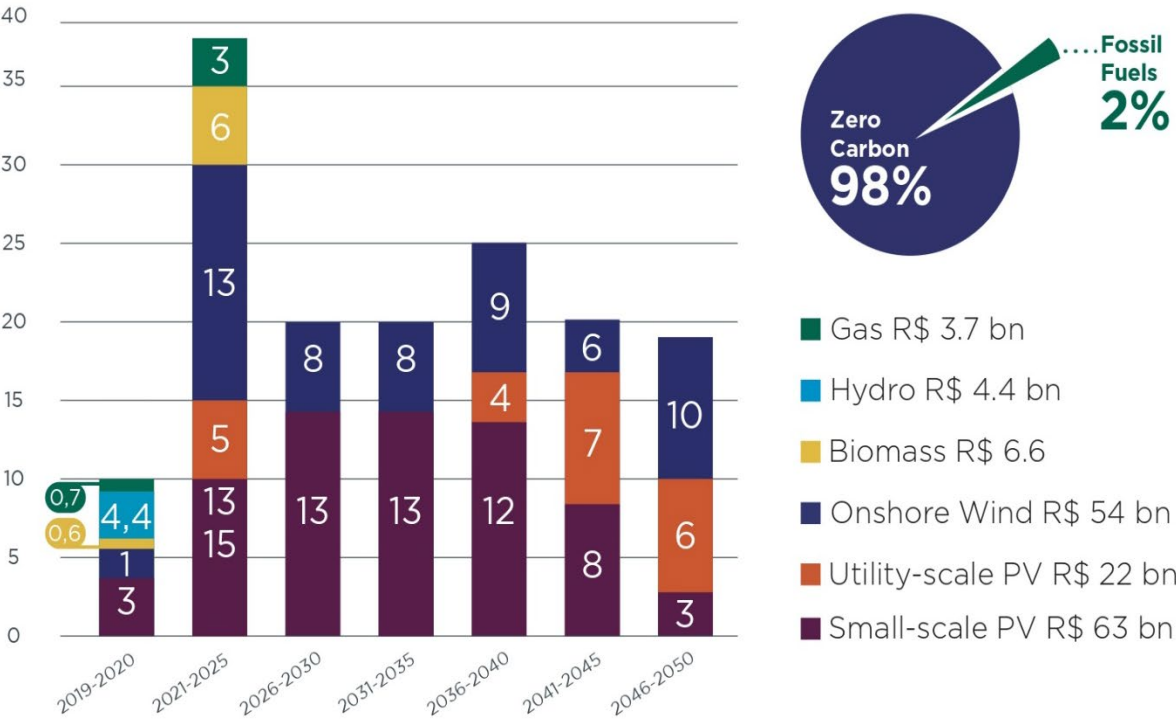
According to PDE 2029, Brazilian National Energy Plan 2029 ⁴

⁴ <https://www.epe.gov.br/en/publications/publications/pde-2029-executive-summary>



2.2 CARBON ZERO DIRECTION

BNEF (Bloomberg New Energy Frame) forecasts that 98% of the investments to be made in new power capacity in Brazil until 2050 will be directed to zero carbon sources (see table below: the total amount of investments per power source over the entire period is mentioned at the right hand side and the spread of those amounts over the various periods can be seen in the chart itself).⁵



⁵ <https://about.bnef.com/new-energy-outlook>



3. WIND POWER IN BRAZIL

In 1992, the first wind turbine in Brazil came into operation. It was installed in the archipelago of Fernando de Noronha, that belongs to the State of Pernambuco. It was the result of a partnership between the Brazilian Wind Energy Center (CBEE) and the Companhia Energética de Pernambuco (CELPE), with funding from the research institute Danish Folkecenter. During the next ten years, wind energy grew little, partly because of the lack of policies, but mainly because of the high cost of the technology.

During the energy crisis of 2001, there was an attempt to encourage the hiring of wind power generation projects in the country. The Emergency Wind Energy Program (**PROEÓLICA**)⁶ was created. This program aimed to contract 1,050 MW of wind energy projects by December 2003. At that time, there was already talk of the seasonal complementarity of the wind regime with the hydrological flows in the hydroelectric reservoirs. This program, however, did not obtain results and was replaced by the Incentive Program for Alternative Sources of Electric Energy, **PROINFA**. In addition to encouraging the development of renewable sources in the energy matrix, PROINFA paved the way for the establishment of the wind turbines and components industry in Brazil with national content requirements for wind turbines resulting from this program.

At the birth of PROINFA, wind power generation technology was still very expensive and the development in competitive auctions would only come later. At the end of 2009, the first energy commercialization auction, exclusively focused on wind power, took place. This auction, called Reserve Energy Auction (LER), was a success with the contracting of 1.8 GW and opened the door to new auctions that took place in the following years.

Since then, wind power has shown solid and consistent growth, and is now a consolidated energy source. Wind power is no longer an “alternative” source in the Brazilian electricity matrix. It is today the second source of the electricity matrix, with more than 10% of participation. What explains this development?

Well, first of all, our winds. To produce wind energy, good winds are needed: stable, with the right intensity and without sudden changes in speed or direction. Brazil is fortunate to have a huge amount of this type of wind, which largely explains the success of wind power in Brazil in recent years. The characteristics of good Brazilian winds result in a capacity factor that is practically double the world average.

This strength of the Brazilian winds means high productivity and, with more and more wind farms operating, wind farms have been breaking record after record during the “wind harvest”, a period that runs from June to the end of the year, reaching the Northeast for a whole day and about 20% of the country.

The success of wind power in Brazil can also be explained by the rapid development of a local and efficient production chain. This started, according to the financing rules of the FINAME Program of the National Bank for Economic and Social Development (BNDES), with a nationalization rate close to 60% and reached in national territory a production of 80% of a wind turbine. Brazil currently has six turbine manufacturers, blade factories and wind towers

⁶ <http://patrocinados.estadao.com.br/o-que-o-brasil-quer/energia-sustentavel/a-evolucao-e-o-futuro-da-energia-eolica/>



and hundreds of companies that work in other components, like transport, various consulting, planning, works, etc.

The development of wind power in Brazil has already an accumulated investment of more than US\$ 42 billion in the last 11 years. In 2021, for example, the investment was US\$ 5.15 billion. The investment data released by ABEEólica (Brazilian Wind Energy Association) are provided by Bloomberg New Energy Finance (BNEF) and can be seen in more detail in the Annual Bulletin of Wind Generation, produced by the association.

Brazil is one of the countries that invests the most in wind energy in the world; it has been classified as a wind power and already occupies the sixth place in the Installed Capacity Ranking of the GWEC, the Global Wind Energy Council. Another factor that explains the efficient development of wind energy in Brazil is its great potential. We estimate that Brazil has a potential on land of more than 700 GW.

According to the national statistics agency and the Central Bank, Brazil's GDP grew by 4.6% in 2021, with a direct impact on electricity consumption which increased by 4.1% compared to the previous year.

In 2021 wind energy reached a milestone of 20 GW of installed capacity in Brazil – equivalent to 70% of all wind power capacity in Latin America – after more than 3 GW was installed in 2021 alone. This record growth was due to a confluence of factors, including economic recovery, increase in demand for electricity and efficiencies from a more consolidated wind energy industry. The year also marked the arrival of new frontiers for wind energy in the country in the form of offshore wind, production of green hydrogen and regulation of hybrid projects.

Wind energy in Brazil has been marked by virtuous growth over the last decade, jumping from 1 GW in 2011 to 21 GW by January 2022. Today, wind is the second largest source of power generation in the country, making up 11% of the electricity matrix. Three factors were decisive for this growth:

- First, the regulatory framework for auctions facilitated procurement of wind energy at competitive prices; and
- Second, financing design that was focused on national content provided Brazil with a solid wind industrial base, with capacity to produce enough turbines to install around 5 GW per year. Most important aerogenerators producers are locally installed in Brazil such as Alstom/GE, Siemens/Gamesa, Vestas, Wobben-Enercon and Nordex/Acciona. These 5 players have 90% of the market share with main assembly of nacelle (wind engine) in Brazil and with over 70% steel plates locally made to meet national content policies and thus apply for financial incentives at FINAME/BNDES.
- The third factor is external: Due to changing weather patterns and drops in reservoir levels for hydropower generation, there is an increasing uncertainty about the role of hydropower in the electricity matrix. During 2021 Brazil experienced the worst hydropower crisis in the last 91 years, making wind the locomotive of the expansion of the Brazilian electric system. Generation reports from last year reflect that wind even supplied 100% of the entire Brazilian Northeast's electricity demand and even had a surplus, according to the National System Operator (ONS). The prospects for investments in the country remain positive, anchored by a regulatory apparatus and solid growth of



the bilateral market for wind energy. According to the Brazilian Wind Energy Association (ABEEólica), sector investment is expected to reach \$5.8 billion in 2022, with up to 5 GW in the pipeline for installation this year. EPE (the state Energy Research Office) estimates investments of around \$59 billion in centralised power generation and another \$20.2 billion in transmission and substations from 2020 to 2029.

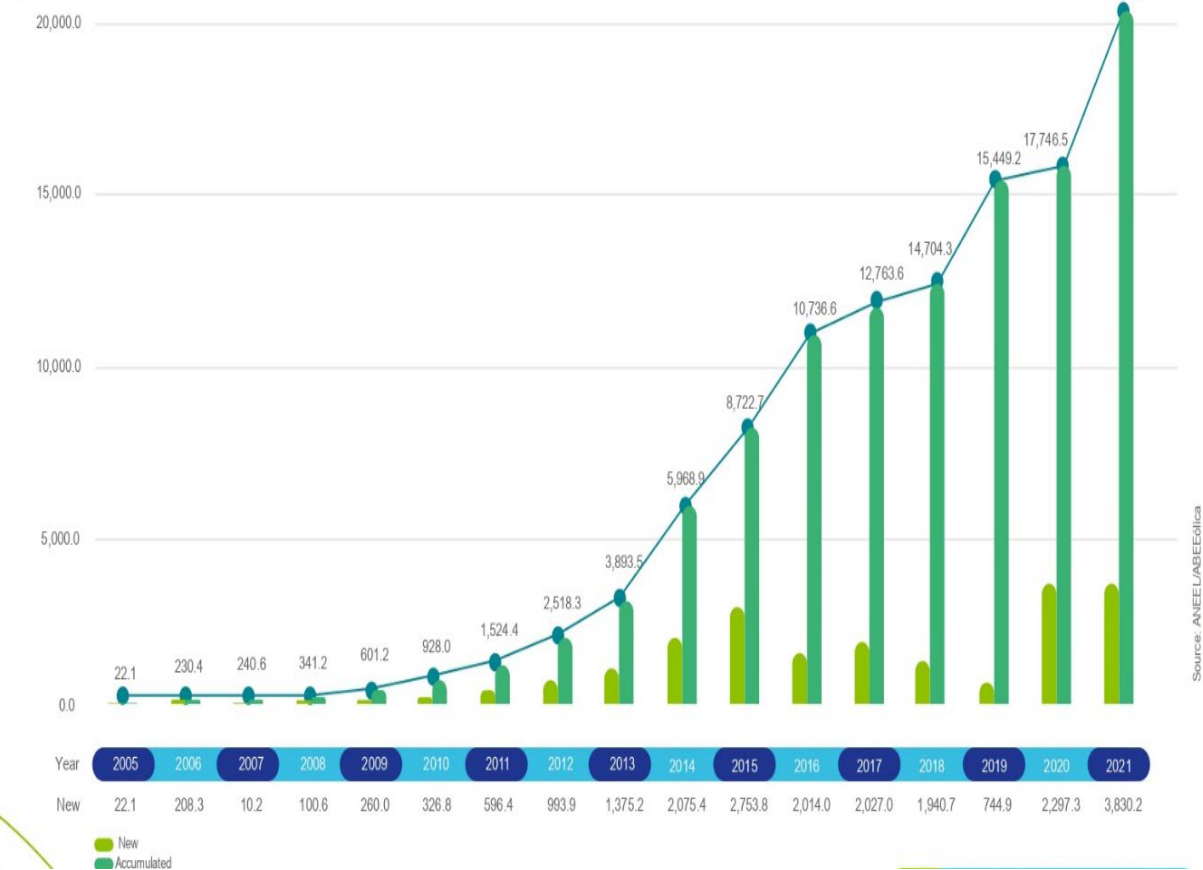


3.2 WIND ENERGY INSTALLED CAPACITY

By the end of 2021 there were a total of 795 plants and 21.57 GW of installed wind energy capacity, a 21.53% growth compared to December 2020, when the installed capacity was 17.75 GW.

Growth of installed capacity (MW)

chart 10

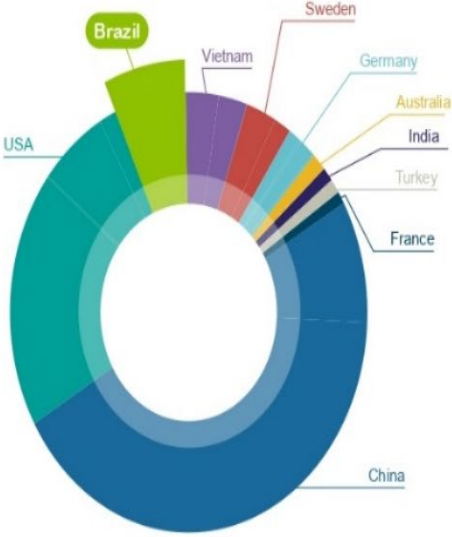


3.2.1 New installed capacity – Wind energy

In 2021, Brazil was the number 3 worldwide in the installation of new windturbines, according to GWEC (Global Wind Energy Council). 110 new wind farms were built in 2021, 1 was cancelled, totaling 3.83 GW in new capacity, a record for wind energy in Brazil.

Top new installed capacity 2021
chart 12

RANKING POSITION	COUNTRY	Power (GW)
1	China	30.7
2	USA	12.7
3	Brazil	3.8
4	Vietnam	2.7
5	Sweden	2.1
6	Germany	1.9
7	Australia	1.7
8	India	1.5
9	Turkey	1.4
10	France	1.2



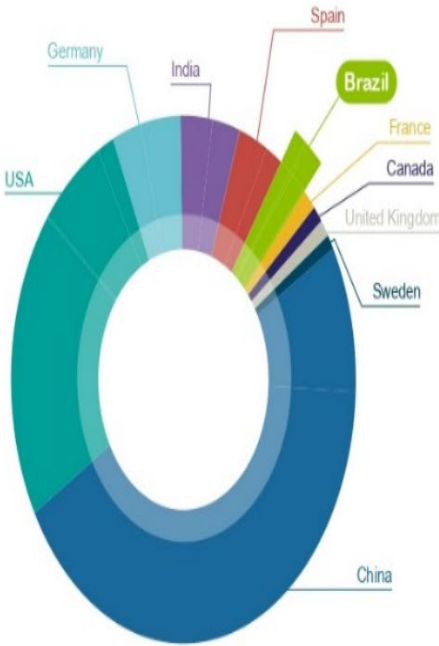
Source: GWEC

3.2.2 Top 10 cumulative capacity in the world – Wind energy

The GWEC also announced that Brazil went up a point in the Global Installed Capacity: Brazil is now on position 6 in the world.

Top 10 cumulative capacity 2021
chart 11

RANKING POSITION	COUNTRY	Power (GW)
1	China	310.6
2	USA	134.3
3	Germany	56.8
4	India	40.0
5	Spain	28.3
6	Brazil	21.5
7	France	19.1
8	Canada	14.2
9	United Kingdom	14.0
10	Sweden	10.0



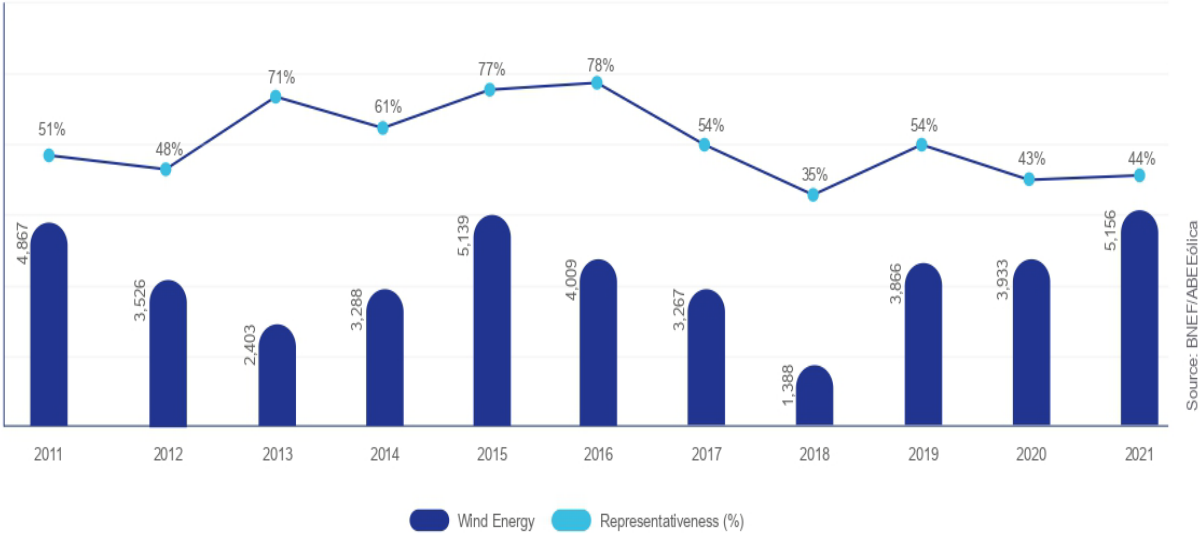
Source: GWEC



3.3 INVESTMENTS IN NEW WIND PROJECTS IN BRAZIL

According to BNEF (Bloomberg New Energy Finance), the total investment in wind energy in 2021 amounted to US\$ 5.15 billion (R\$ 27.81 billion) or 44% of the total investment in renewables (solar, wind, biofuels, biomass, PCHs/Small hydro and other sources) in Brazil.⁷

Investments in new wind energy project (US\$ Million)
chart 13



Source: BNEF/ABEEólica

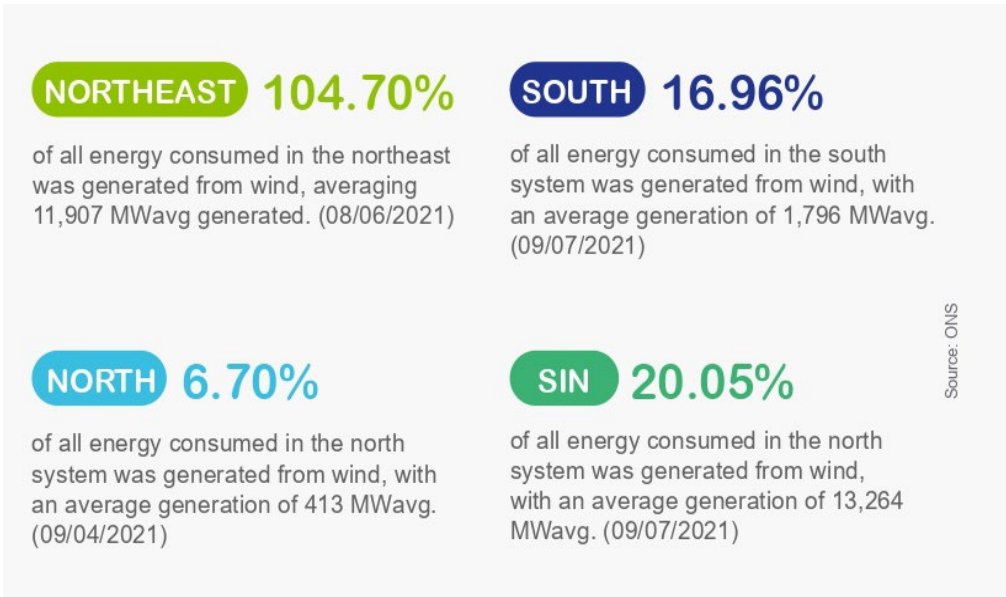
3.4 WIND POWER SUPPLY RECORDS

In terms of percentage and supply, wind power accounted for 12.18% of all the electricity generated and added to the National Interconnected System (SIN) in 2021. Winds peak in the second half of the year, as does wind energy, peaking in August at 16.77% of the SIN/National Interconnected System generation.

In 2021, wind energy generation broke a number of monthly records in the windier months. Below are the records for the year in each SIN subsystem:

⁷ <https://abeeolica.org.br/en/wind-energy/the-sector/>

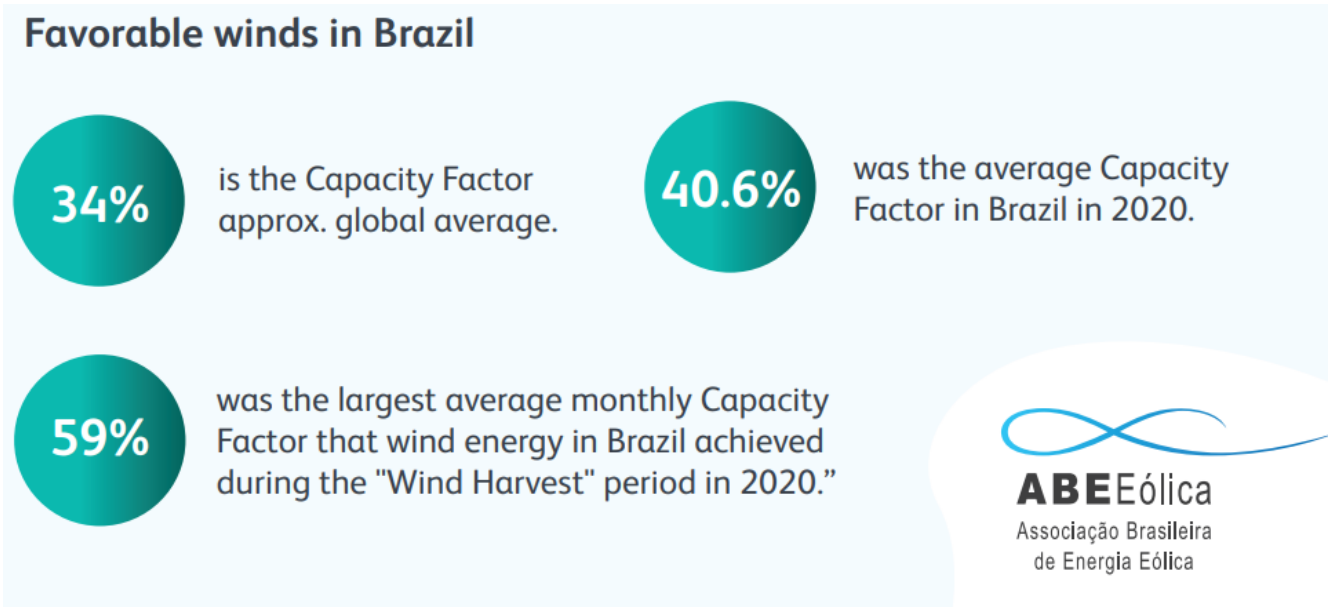




Source: ONS (national system operator)

3.5 THE SUPERB QUALITY OF THE WINDS OF BRAZIL

The favorable quality of Brazilian winds for wind power generation stands out globally. Brazil has a capacity factor (wind productivity) that is above average, as you can see below.⁸



⁸ <https://abeeolica.org.br/en-global-wind-day-brazil-completes-16-gw-of-wind-power-installed-capacity/>



3.6 BRAZILIAN STATES WITH HIGHER WIND ENERGY GENERATION

The five states with the greatest amount of energy from wind in 2021 were Rio Grande do Norte (21.23 TWh), Bahia (21.15 TWh), Piauí (9.10 TWh), Ceará (7.91 TWh) and Rio Grande do Sul (5.63 TWh).

REGION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RN	1,602.4	1,144.7	1,082.3	1,208.3	1,346.9	1,521.0	2,066.1	2,532.7	2,309.3	2,162.7	2,093.0	2,162.7
BA	1,573.8	854.9	1,362.8	1,402.9	1,784.1	1,864.2	2,200.7	2,362.6	2,155.0	1,884.7	1,823.9	1,884.7
PI	570.7	274.5	358.6	547.3	881.9	926.7	1,126.4	1,126.0	982.3	777.7	752.6	777.7
RS	453.8	365.6	364.0	461.6	443.3	521.4	452.8	444.8	530.1	537.1	519.8	537.1
CE	696.8	487.5	338.4	413.7	361.2	462.6	704.2	865.4	915.9	897.8	868.8	897.8
PE	280.9	205.9	206.1	171.6	202.2	176.1	251.8	289.3	270.9	296.4	286.8	296.4
MA	172.2	117.9	78.4	93.7	53.0	84.3	104.5	182.9	226.6	219.1	212.0	219.1
PB	46.3	30.6	33.3	35.2	42.8	43	56.4	69.6	110.7	115.0	111.3	115.0
SC	49.4	32.4	34.7	36.3	43.4	49.2	61.1	64.2	54.5	46.3	44.8	46.3
SE	5.5	5.3	4.7	2.8	3.5	3.1	3.9	6.0	5.5	6.1	5.9	6.1
RJ	9.9	4.7	3.8	2.2	2.1	2.9	3.2	6.2	6.2	4.9	4.8	4.9
PR	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.3	0.3	0.3	0.3

Source: CCEE/ABEEólica

Source: CCEE⁹

⁹ <https://www.ccee.org.br/pt/web/guest/-/brasil-deve-ganhar-quase-250-usinas-eolicas-e-fazendas-solares-ate-2026-aponta-ccee>

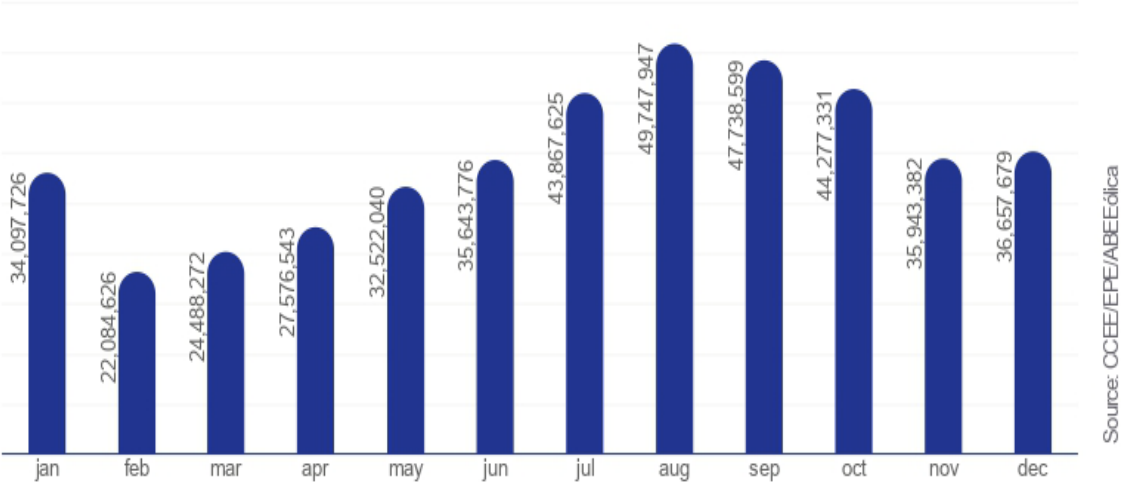


3.7 WIND POWER CONTRIBUTION TO RESIDENTIAL SUPPLY

Wind energy can also be represented as wind generation compared to the average home use of electric energy in Brazil. According to the monthly review published by EPE (Empresa de Pesquisa Energética or Energy Research Company), the average residential consumption in 2021 in Brazil was 166 kWh per month.

This means that the average wind generation in 2021 was equivalent to the average power consumed by 36.2 million homes, or some 108 million inhabitants (around half the population of Brazil of 210 million inhabitants!) or more people than the population of the entire region of the Northeast of Brazil (over 108.5 million people).

Households powered by wind in 2021, month by month
chart 7



Source: Bloomberg NewEnergy Finance – BNEF ¹⁰

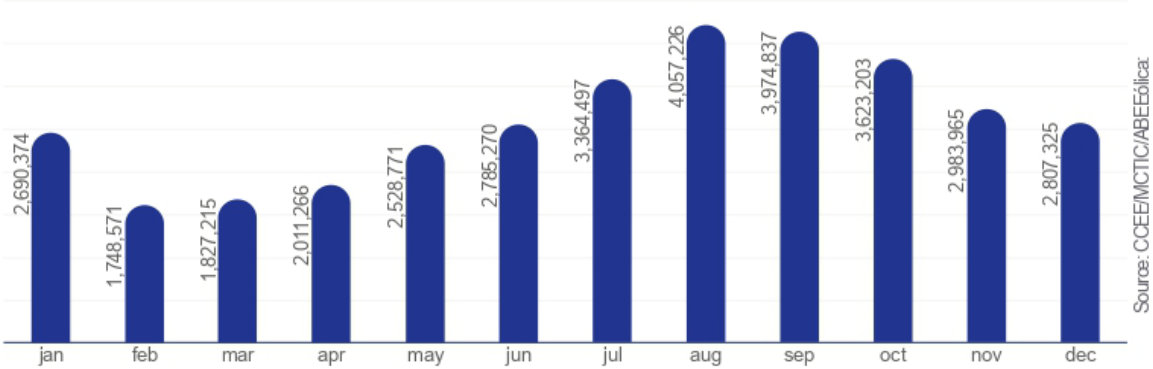
¹⁰ <https://www.bloomberg.com/professional/blog/webinar/bloomberg-new-energy-outlook-2020-america-latina-brasil/>



3.8 ADVANTAGES OF WIND POWER INSTALLATIONS IN BRAZIL

In 2021, the energy generated by winds prevented the emission of 34 million tons of CO₂ in the country, according to the Brazilian Wind Energy Association (ABEEólica). The amount is equivalent to the carbon dioxide emitted by around 34 million passenger cars and demonstrates the fundamental role of renewable energies – and wind energy in particular – in the process of transition to a low-carbon economy.¹¹

Avoided CO₂ emissions in 2021 (Million tons)
 chart 8



Tons CO₂ avoided in 2021: 34.4 million.

¹¹ <https://fullenergy.grupomidia.com/energia-eolica-evitou-emissao-de-344-milhoes-de-toneladas-de-co2-no-brasil-em-2021/>



3.9 WIND INSTALLATIONS SUPPORT LOCAL COMMUNITIES

In addition to the benefits described in this document, wind energy has a positive impact on the communities due to social, cultural, healthcare and environmental projects undertaken for the development of the local population. Below are a few examples of community projects undertaken by wind energy players:



Measures that promote water security and enable access to water for production and human consumption, reaching isolated communities.



Activities to encourage sports, alongside help for schoolwork.



Digital inclusion activities, training youth and adults, and fostering employability and enterprise.



Fostering regional tourism, art, gastronomy, and culture with festivals, courses, training, and contests.



Strengthening and expanding local production chains such as coconut, manioc, corn, beans, honey and milk, among others to improve the population's income and promote sustainable development.



Encouraging local artisans.



Health promotion projects including oral health and nutrition, for instance.



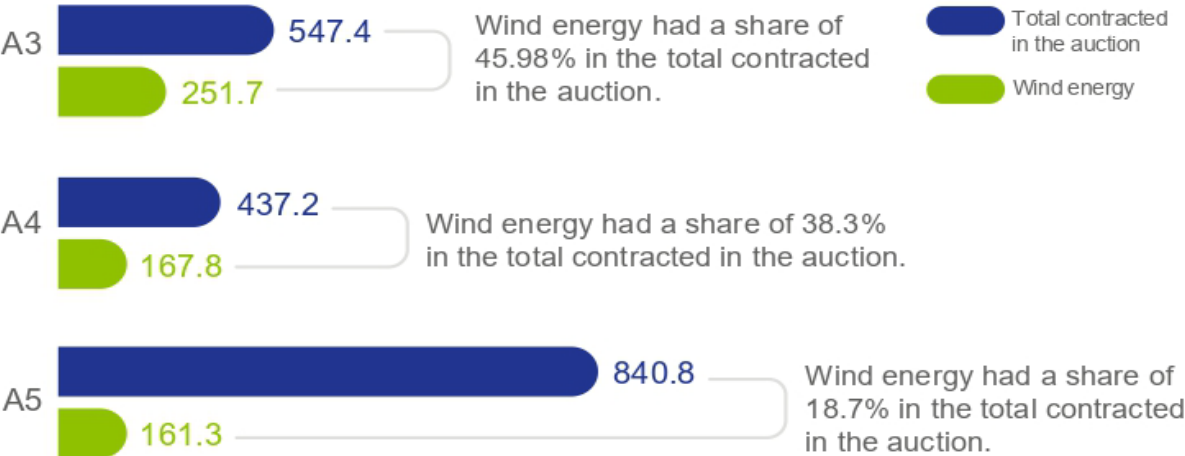
Educational projects such as day-care centers and schools, with initiatives to increase the quality of life of students in public schools, with citizenship activities, educator training, and better school environments, promoting discussions on sustainable development and renewable energy.



3.10 ENERGY AUCTIONS AND FREE MARKET SALES

580 MW of installed capacity were contracted in three auctions in 2021 (see A3, A4 and A5 below) with around 40% coming from wind sources.

Brazil also had a good year in the free market. These numbers are not consolidated in any database as these transactions are not necessarily public; however we estimate that in general wind farms sold some 3 GW to the freemarket in 2021. More wind energy was sold in the free market than in the regulated market for the fourth consecutive year.



4.1 OFFSHORE WIND PROJECTS

After the publication of the Decree 10,946/2022 mentioned before, the number of new environmental licensing processes for offshore wind projects intensified at IBAMA (the Brazilian Institute of the Environment and Renewable Natural Resources).

IBAMA set rules such as the Terms of Reference/TR aimed at determining general technical guidelines and criteria that should underpin the elaboration of the Environmental Impact Study/EIS and its Relatório de Impacto Ambiental/RIMA (Environmental Impact Report) in order to subsidize the previous environmental licensing process of Brazilian Institute of Environment and Renewable Natural Resource/IBAMA.

The investor’s appetite and potential are enormous. In April 2022, there were already more than 100 GW of projects under analysis at IBAMA and the EPE Wind Roadmap shows a potential of 700 GW. This is a potential that is usually called “infinite”, because considering the technical need to have a diversified electrical matrix, no one would bet on a single source and Brazil will probably not need all this energy from sea winds.

Figures 7.1, 7.2, and 7.3 below present the location of the projects along the coast. The figures are taken from a map issued by IBAMA; the last revision dated 2 August 2022.

As seen in the figures, many projects are superimposed on others, indicating that they are mutually exclusive. In case there is more than one project and all are suitable to move on, it is not clear yet how the authorities will decide which project will prevail.

Table 7.1 presents relevant data of all projects. The table is also part of the map issued by IBAMA, and it is a great source to identify the companies already involved. One can identify that some projects are superimposed as they were submitted to IBAMA earlier.

Relevant international oil companies, such as Shell, Equinor and TotalEnergies are already making their presence felt in the Brazilian offshore wind market; together with other well-known companies such as Neoenergia, controlled by Iberdrola.¹²

¹² http://www.ibama.gov.br/phocadownload/licenciamento/2022-08-11_Usinas_Eolicas_Offshore_Ibama.pdf



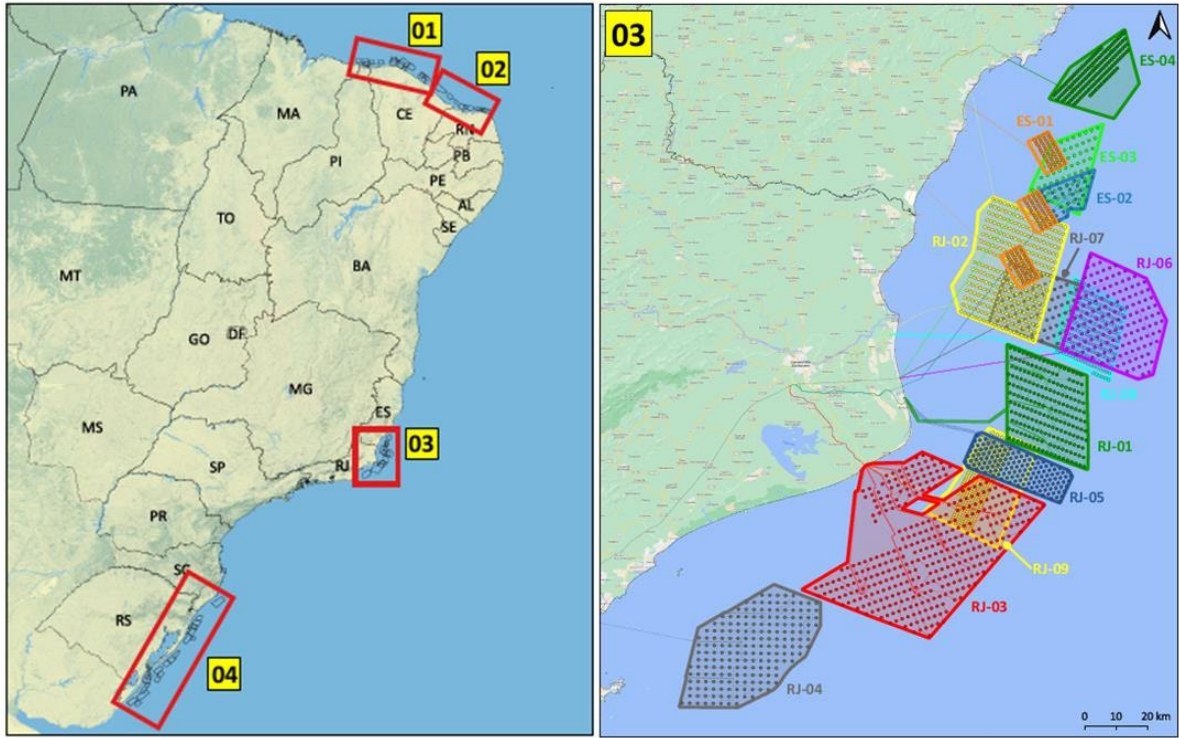


Figure 7.1: Projects under Environmental Licencing at IBAMA
 Map Source: IBAMA (August 2022)



Figure 7.2: Projects under Environmental Licencing at IBAMA
 Map Source: IBAMA (August 2022)

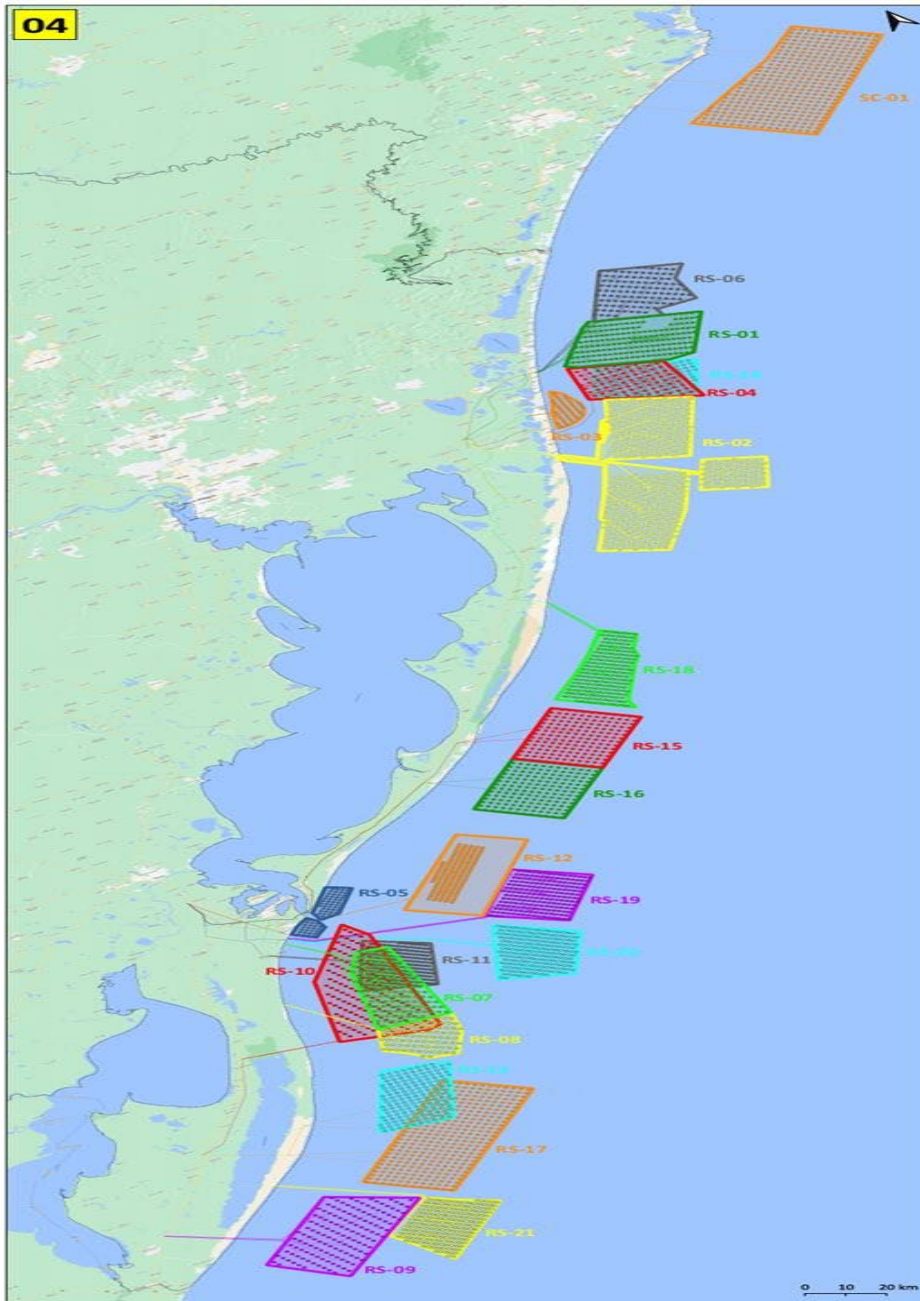


Figure 7.3: Projects under Environmental Licensing at IBAMA
Map Source: IBAMA (August 2022)



5. GREEN HYDROGEN: NEAR FUTURE FOR BRAZIL

WHAT IS GREEN HYDROGEN

Hydrogen is the simplest element and common in the Universe. A totally clean process, because of the absence of carbon dioxide production or carbon monoxide in its burning, where the result of the process is only the formation of water. It can be isolated and used as fuel. It has an energy potential 3x greater than that of gasoline and diesel oil.

Green hydrogen is a fuel produced from renewable energies such as wind and solar. Its production takes place without the emission of carbon. And so that experts understand this type of fuel as key to a carbon neutral world.

Green Hydrogen is a promising technology because it carries some advantages related to storage, energy security, reduction of price volatility, adaptability of renewable energy systems and fuel production and transport. Recently, IRENA released the report “Green Hydrogen: A Guide to Policy Making”¹³, The document shows that different countries have created national plans for the production of hydrogen from renewable sources. Countries such as Germany, France, Spain, Japan, China, Chile and Norway have already outlined their hydrogen production strategies via renewable sources. This shows that hydrogen can be a driving mechanism for the installation of new renewable energy capacity and make this type of source increasingly competitive.

The EPE took the first step in the national context and in early February launched the technical note called: “Bases for the Consolidation of the Brazilian Hydrogen Strategy”.¹⁴ The document raises the main initiatives related to hydrogen that Brazil has carried out and their opportunities and challenges. The material reinforces the need for Brazil to have a strategy for the production of hydrogen from various energy sources existing in the country to generate a competitive advantage in the industry. The role of Green Hydrogen is highlighted due to its potential to generate competitiveness. The document mentions that renewable sources can reduce hydrogen production prices by up to 60% by 2030. Advancing a hydrogen strategy, as proposed by the EPE, can help Brazil to become an important player in the international market in terms of commercialization of this fuel, based on the competitiveness of the country’s renewable sources and on the current discussions and climate agreements signed between the countries.

BRAZILIAN POTENTIAL IN GREEN HYDROGEN PRODUCTION

The abundance of quality wind in Brazil enhances onshore and offshore production and increases the opportunity for production of green hydrogen in the country.

JOB GENERATION

According to IRENA, it is estimated that 17 jobs are needed for each MW of offshore wind, over a 25-year lifespan of a 500 MW project.

¹³ <https://www.irena.org/publications/2021/May/Green-Hydrogen-Supply-A-Guide-To-Policy-Making>
¹⁴ [https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-569/NT_Hidrogeno-EN_revMAE%20\(1\).pdf](https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-569/NT_Hidrogeno-EN_revMAE%20(1).pdf)



BRAZIL WILL BE AN IMPORTANT GLOBAL PLAYER.

Considering that energy costs correspond to approximately 70% of the total production costs of green hydrogen, Brazil will have the lowest cost of green hydrogen produced from the wind source in 2030 when compared to other countries in the world, due to the abundance and low costs linked to this source in the country.

Currently more than 200 billion dollars of investments have been mapped into projects and have been announced or agreed upon via memorandums of understanding (MoUs).

FIRST OPERATIONS

UNIGEL, the first green hydrogen factory in Brazil, is already under construction at the pole industrial center of Camaçari – State of Bahia.¹⁵

With an estimated investment of US\$ 120 million, the Unigel factory will start producing in 2023. The production capacity will be 10,000 tons of green hydrogen per year, which will be converted into 60,000 tons of green ammonia.¹⁶

OTHER OPERATIONS TO START SOON

There are projects for the near future at Porto do Açu, State of Rio de Janeiro and in the Port of Pecém in the State of Ceará.

¹⁵ <https://www.reuters.com/business/sustainable-business/brazils-unigel-build-green-hydrogen-plant-with-120-mln-investment-2022-07-25/>

¹⁶ <https://www.capitalreset.com/unigel-primeira-fabrica-de-hidrogenio-verde-do-brasil/>



6. SOLAR ENERGY IN BRAZIL

Solar energy has been growing fast in Brazil and ranks third in energy generation.¹⁷ According to the Brazilian Photovoltaic Solar Energy Association (Absolar), solar energy ensures 90% monetary savings when compared to electricity stemming from other sources.

The country surpassed the mark of 22 gigawatts (GW) of installed potency of the photovoltaic solar source at the end of 2022 (see figure on page 5). Of this total, 20,46 GW are power plants installed on rooftops, facades and small plots of land. The other 7% is linked to large plants.

The number is considered historical by the sector and, hence, the National Confederation of Industry (CNI) estimates that the installed capacity could double by the end of 2023.

Absolar President, Rodrigo Sauaia, said that the growing readjustments in the electricity bills and the reduction in costs for the installation of photovoltaic plates explain the growth of this type of energy in the country. Solar energy is considered a clean source, which does not produce waste or pollution.

According to Absolar, this energy avoided the emission of almost 28 million tons of CO2 (carbon dioxide) in the generation of electricity in 2022.

Solar photovoltaic is becoming increasingly more accessible and popular due to its several advantages. Today, it is already cheaper to generate your own electricity from the sun than to buy it from your local utility company as the investments normally pay themselves back in 5 years.

To facilitate paying for this investment, financing is already a competitive option for consumers who wish to add a solar photovoltaic (PV) system to a commercial or residential building. Many financial options from public and private agents are available for different sectors of the Brazilian economy.

Installation costs, however, are not low. For households, the average price is R\$ 25,000 (around US\$ 4,725), and for industries it goes up to R\$ 200,000 (around US\$ 37,785). Mr Sauaia also pointed out that these values should be dropping shortly. With the reduction in monthly bills, the investment is recovered in a few years.

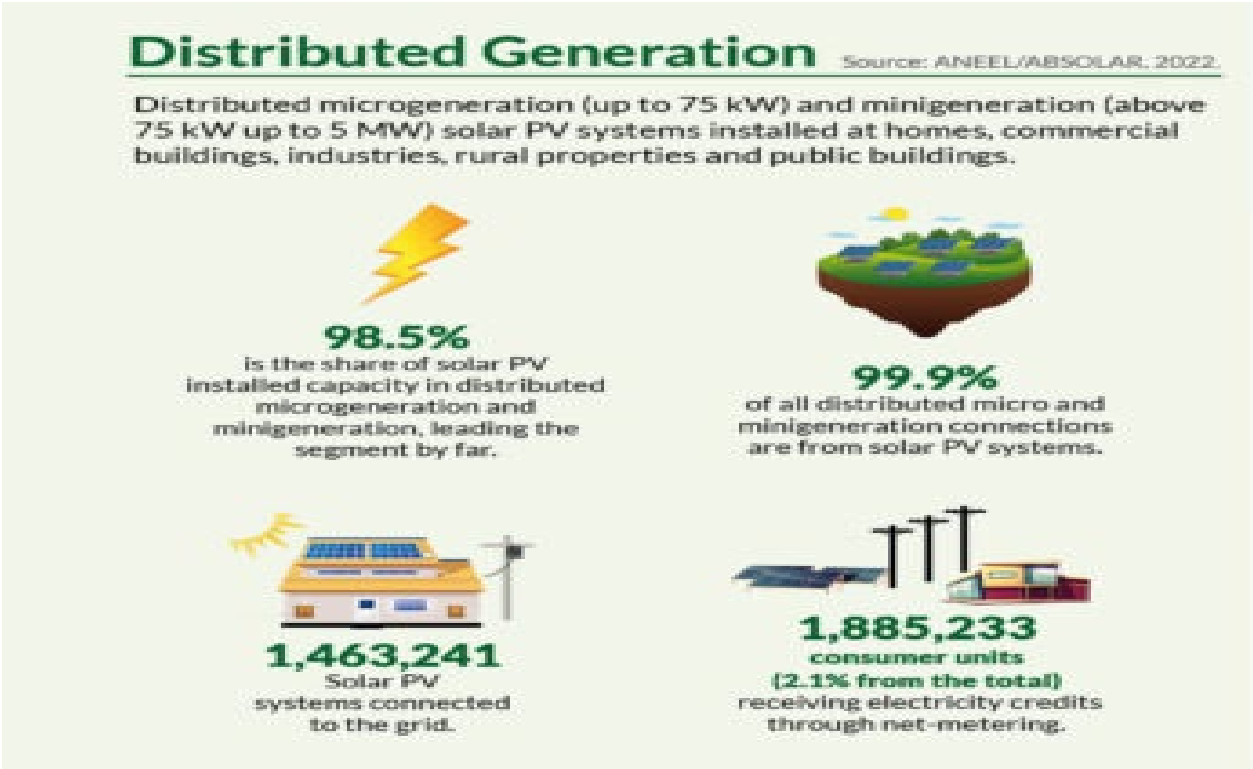
Since 2012, according to Absolar, solar energy generated new investments in Brazil worth R\$ 113.3 billion (around US\$ 21.3 billion), as well as 670,000 additional jobs .

¹⁷ <https://agenciabrasil.ebc.com.br/economia/noticia/2022-12/uso-de-energia-solar-cresce-no-pais-com-19-gw-de-potencia-instalada>



6.1 THE SOLAR SECTOR IN BRAZIL IN A NUTSHELL

- Over 22 GW installed capacity (2022)
- Over R\$ 113.3 billion (US\$ 21.3 billion) in new investments
- Over 670,000 new jobs created
- Over R\$ 35.5 billion (US\$ 6.70 billion) in collected taxes
- Over 31.1 tons of CO2 emissions avoided
- 98.5% of micro and mini energy generation comes from photovoltaic energy in Brazil
- 1,885,233 consuming units in Brazil receiving credits from the Electric Energy Compensation
- 1,463,241 photovoltaic systems connected to the main electric network distribution
- The most competitive energy source in the energy auctions in 2019



6.2 BRAZIL'S HIGH LEVELS OF INSOLATION

BRAZIL: ONE OF THE HIGHEST LEVELS OF INSOLATION IN THE WORLD

Solar energy has great potential in Brazil, with the country having one of the highest levels of insolation in the world: 4.25 to 6.5 sun hours/day.¹⁸

Notice that most of the potential is in the Northeast and Center-West Region of Brazil because of high levels of insolation in these areas. Those areas are highlighted in orange in the map below:

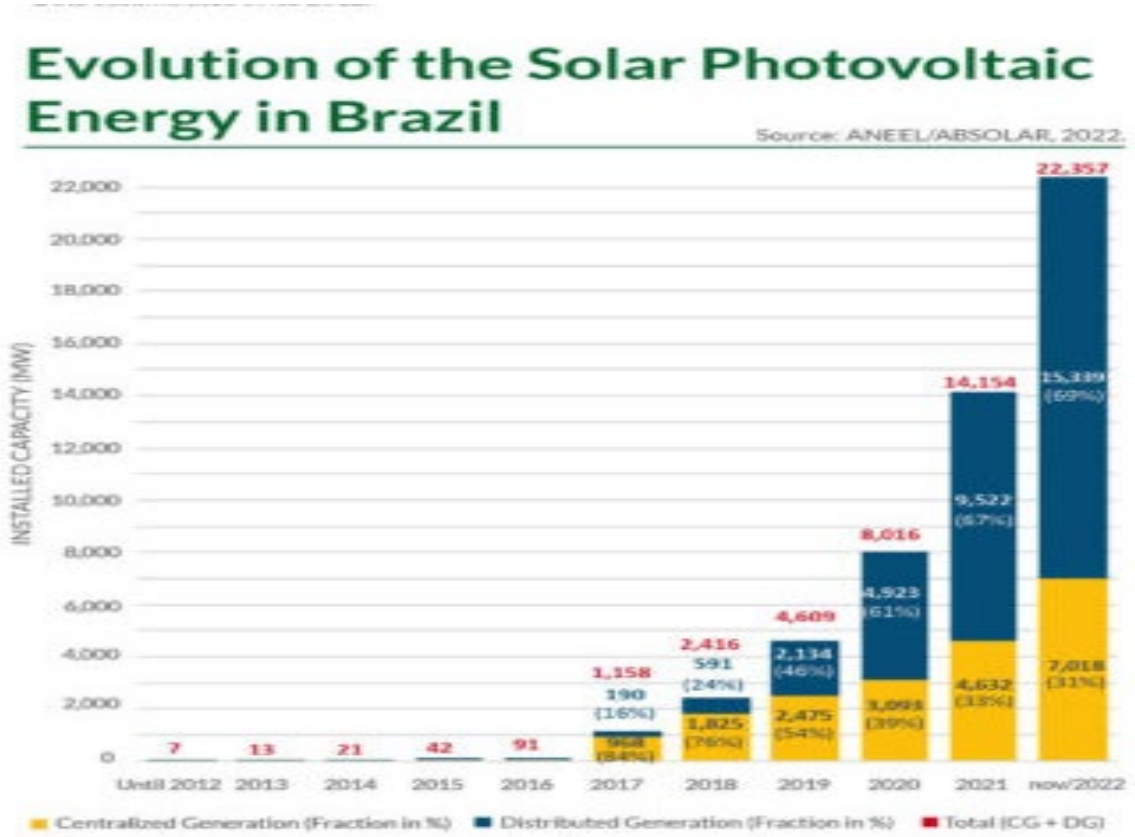


¹⁸ www.solargis.info



6.3 INSTALLED CAPACITY

Brazil reached 22.35 GW installed capacity in 2022, with 15.33 GW of distributed generation and 7.01 centralized generation, a value foreseen to be achieved only by 2029.¹⁹

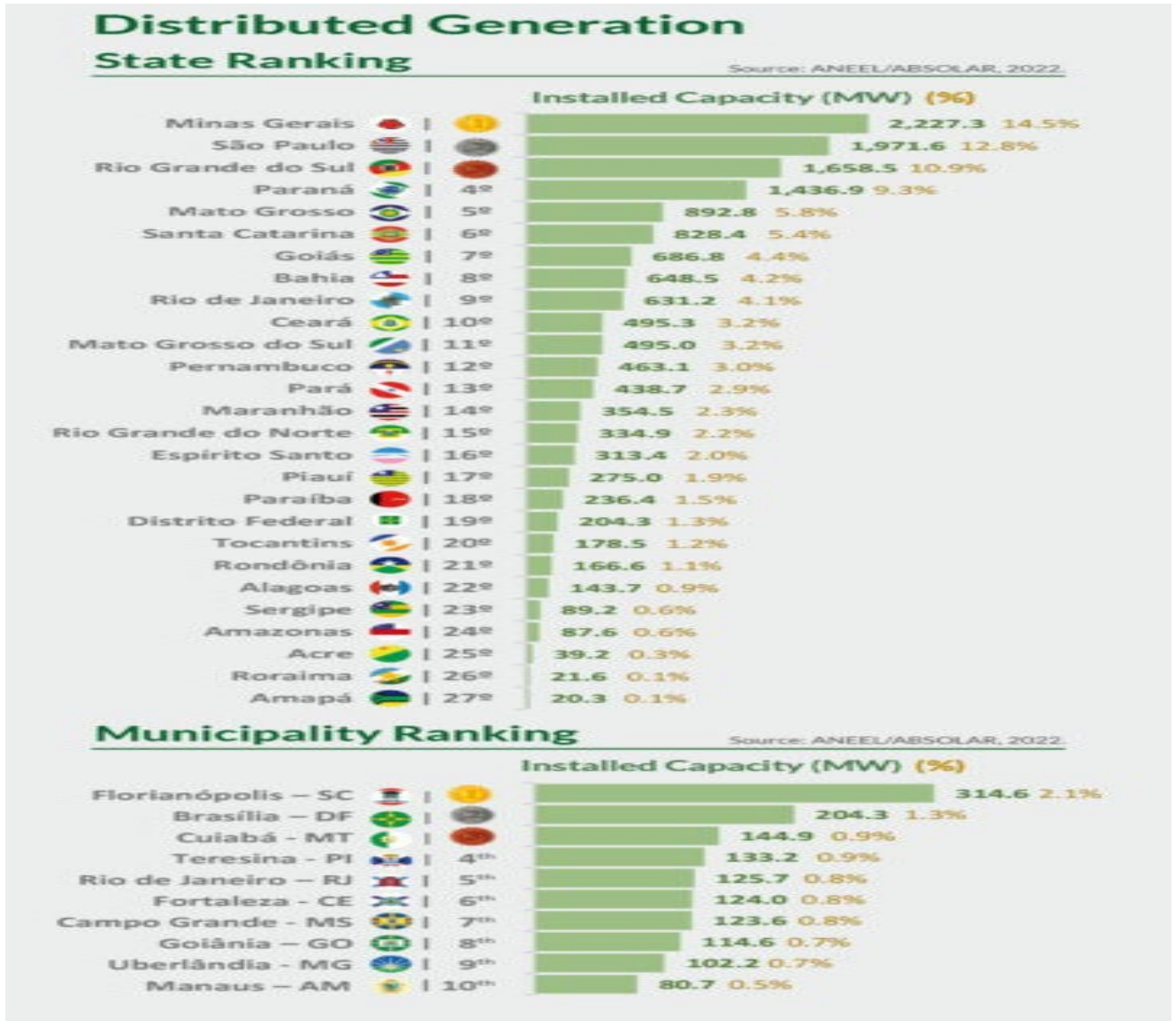


¹⁹ <https://www.absolar.org.br/market/infographic/>



6.4 DISTRIBUTED GENERATION BY STATES AND MAJOR CITIES

In the figure below one can find the distributed solar generation by each Brazilian Federal State (27 in total). The State of Minas Gerais stood out with 2.22 GW, São Paulo with 1.97 GW and Rio Grande do Sul with 1.65 GW of installed capacity. You can also check the Brazilian cities with highest solar PV installed capacity.²⁰



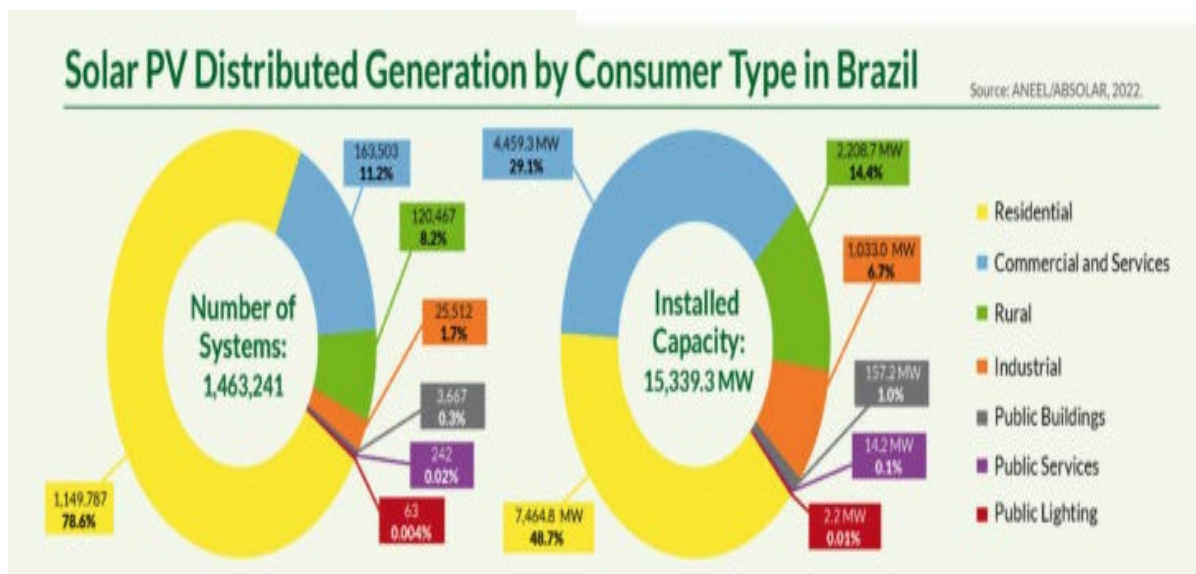
²⁰ <https://www.absolar.org.br/market/infographic/>

6.5 DISTRIBUTED GENERATION BY CONSUMER TYPES

The solar power installed on Brazilian rooftops totaled 15.33 gigawatts at the end of 2022, a strong and steady growth in comparison to the 9.21 GW of production capacity that existed at the end of 2021. According to the 10-year power expansion plan of Empresa de Pesquisa Energética (EPE), this installed capacity is expected to reach 37.2 GW by the end of 2031.

Today, photovoltaic power represents 98.1% of this type of generation.²¹

With 1,463,241 PV solar systems installed, 48.7% of the energy produced is for residential use, 29.1% for commercial services, 14.4% for rural areas, 6.7% for industrial purposes, 1% is for public buildings, 0.1% for public services and 0.01% for public lighting.²²



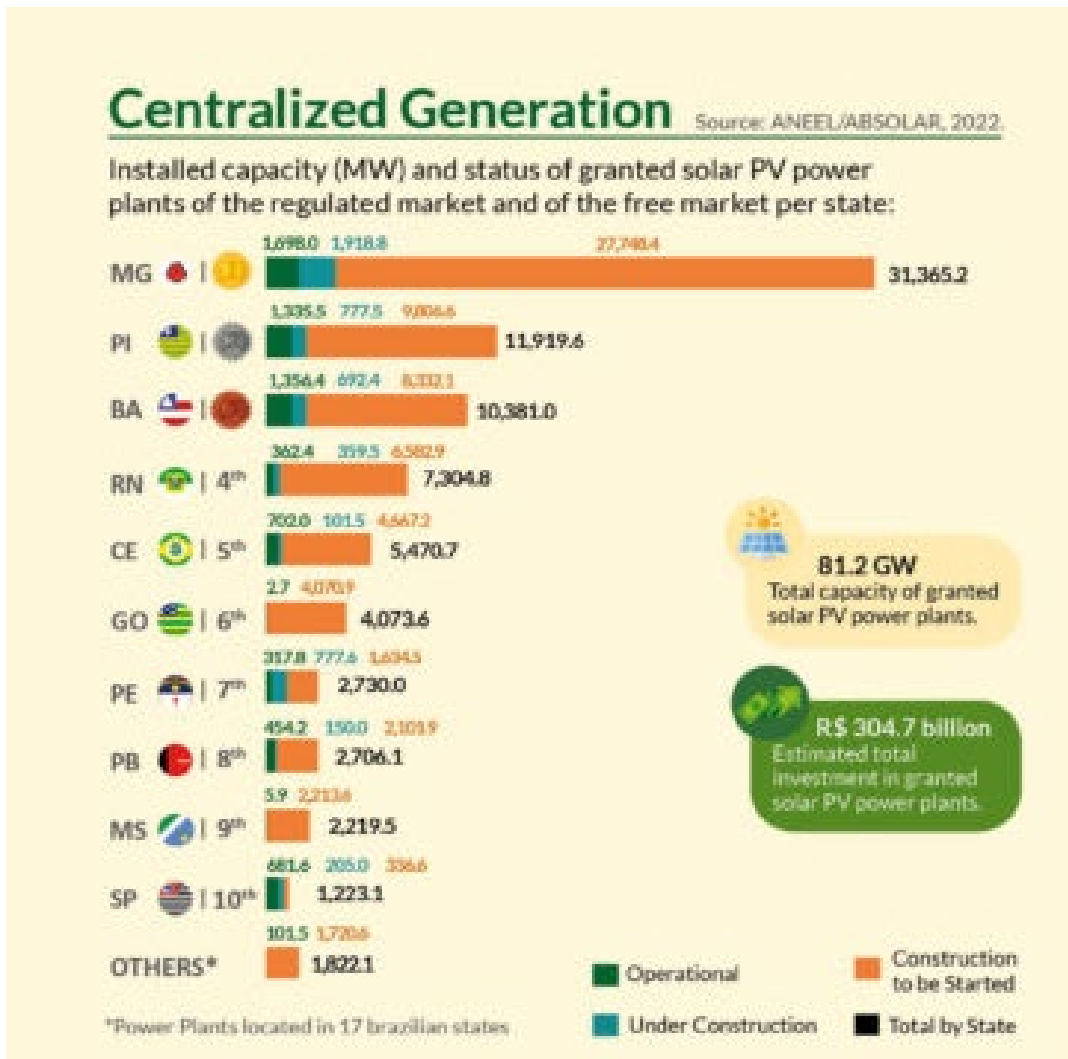
²¹ <https://valorinternacional.globo.com/business/news/2022/10/17/solar-generation-grows-in-brazil-driven-by-tax-break.ghtml>

²² <https://www.absolar.org.br/market/infographic/>

6.6 CENTRALIZED GENERATION BY 10 MAJOR PRODUCING STATES IN BRAZIL

As presented in the figure below the total capacity of granted solar PV power plants is already at 81.2 GW, representing an estimated total investment of R\$ 304,7 billion (US\$ 59,60 billion). ²³

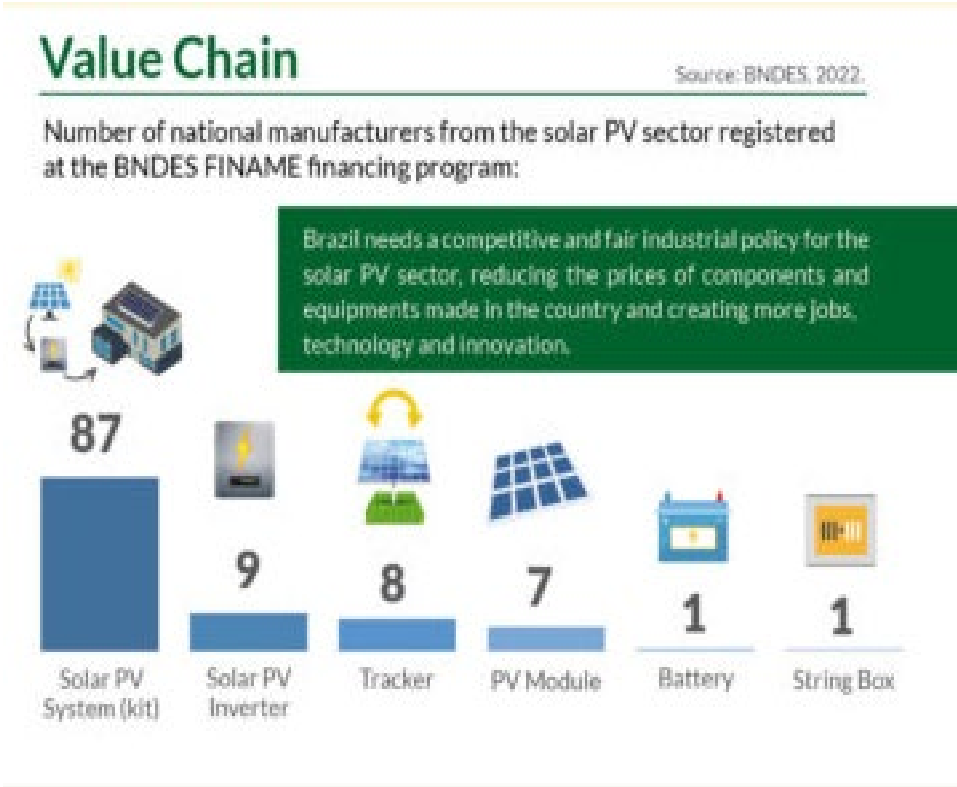
Notice that most of the potential is in the North/Northeast regions of Brazil because of high levels of insolation in those areas.



²³ <https://www.absolar.org.br/market/infographic/>

6.7 NATIONAL PV SOLAR MANUFACTURERS

Brazil has 87 solar PV system kit national producers, 9 Solar PV inverter producers, 8 tracker producers, 1 battery and 1 string box producer. All of them are funded by the FINAME Program of the National Bank for Economic and Social Development (BNDES).²⁴

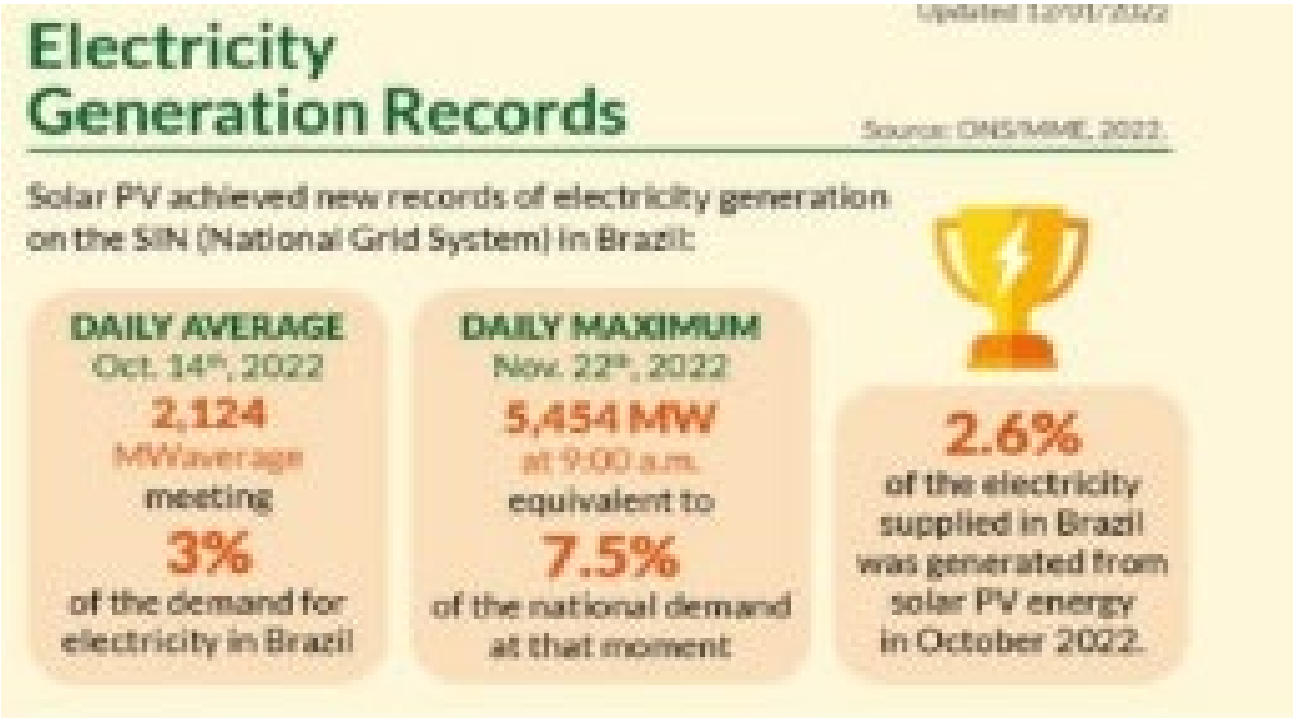


²⁴ <https://www.absolar.org.br/market/infographic/>



6.8 ELECTRICITY GENERATION RECORDS

- 2.6% of the electricity supplied in Brazil on the SIN (National Grid System) was generated from solar PV by October 2022.
- Daily average was 2,214 MW meeting 3% of the electricity demand
- Daily maximum was 5,454 MW meeting 7.5% of the electricity demand²⁵



²⁵ <https://www.absolar.org.br/market/infographic/>



7. FREE AND REGULATED ENERGY MARKET

Renewable Energy represents over 80% of the country's electricity generation capacity. It is the 9th largest power consumer and producer in the world. Brazil has one of the cleanest electricity matrixes in the world.

Brazil's renewables sector opportunities are mainly concentrated on the Northeast, part of the Southeast and South of the country. These regions together, in terms of wind and solar, represent over 90% of installed capacity and new projects of power generation are developed there.

Electricity generation from wind and solar PV sources is estimated to increase to 150 GW until 2040, representing 44% of the Brazilian energy matrix.

Some facts:

- From 2010 to 2020, Brazil attracted over USD 20 billion in FDI (Foreign Direct Investment) for renewable energies
- Brazil is expected to sum USD 150 billion in investments in renewables until 2050
- 80% of the industrial power consumption comes from the Free Market.

Also, the sector has two complementary models, the Regulated Market and the Free Market, and there are business opportunities in both.

Brazil's Regulated Market is an auction model for power generation supply, including renewable sources, which is planned, implemented and hired by the government.

The success of this model is explained by strong incentives, 20-year or longer Power Purchase Agreements, and clear and reliable regulation. Only in the A-6 auction, held in 2019, 1 GW for wind and 530 MW for solar were traded.

The energy traded in auctions from 2018 to 2022 represented approximately 5-10% of Brazil's installed capacity.

Four big auctions were scheduled for 2021 and 2022, bringing excellent opportunities for the sector.

The Free Market is a b2b model, a type of corporate sourcing in which the main advantage for the parties is the possibility to negotiate the power price.

The Free Market is an increasing and flexible corporate sourcing model, which currently corresponds to 30% of Brazil's power demand and approximately 80% of the industrial consumption. An increase of 1,000 TWh in electricity consumption is expected, which will generate the need for USD 150 billion in investments in renewable energies until 2050.²⁷

²⁷ <https://investinbrasil.com.br/content/portaldoinvestidor/us/home.html#tabs-c47da88e24-item-37cfa82e74-tab>



It is estimated that, from 2000 to 2020, 30% of savings were made due to this model.

Today, a demand of 2000 MW is necessary to play in this model, but in order to open the Free Market for more players, the Government will gradually reduce this demand to 500 kW until 2023.

The government is already studying ways to open the Free Market even more after 2023. The Brazilian Development Bank (BNDES) has created a reference price (Preço de Referência) for the Free Market, diminishing the risks and incentivizing investments in this model.



8. CHALLENGES AND OPPORTUNITIES

New business models are emerging and will continue to attract investors interest. Hybrid projects²⁸, which co-locate onshore wind and solar generation, was the subject of the recent Normative Resolution 954/2021. This regulation will allow the installation of power plants that combine sources of generation, whether from photovoltaic plants (PVP), wind plants (WPP), large and small hydroelectric plants (HPP/SPP), and thermoelectric power plants (TPP). There are also discussions about hybrid projects combining storage, offshore wind and hydrogen. The offshore wind decree 10,946 (see page 22), which was signed in early 2022, already allows the production of electricity via technological islands, giving space to projects where offshore wind directly produces green hydrogen.

We believe these decrees not only meet public and collective interests but is also an important platform for companies to work in an organized and cohesive way. In an industry that is in its infancy, this security is essential so that companies, society, and the government know the technical criteria and demands and which studies will be required.

Offshore wind energy is more complex than onshore. Investors now have their eyes on Brazil, reflected in the licensing requests for more than 100 GW in offshore wind projects submitted to the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA). This is just a fraction of the technical resource potential in Brazil, which is more than 700 GW, according to EPE's roadmap. EPE further provides a conservative forecast that by 2050, Brazil will reach 16 GW of installed offshore wind capacity, with a 20% CAPEX reduction.

The expectation is that the first offshore wind auction will be held in 2023. Until then, there is much work to be done, from upgrading port infrastructure, building out transmission, increasing public institutional resourcing and advancing the implementation of a "one stop shop" concept for permitting, among other regulations that will be dealt with through ordinances and resolutions.

For the next decade of wind energy growth to be as virtuous as the last, it is essential that wind energy plays a central part in the country's energy, economic and environmental planning. Strategic planning and public policies need to follow the move towards a clean, competitive and fair energy transition, with a view to diversifying the power matrix.

It seems that the growing path of the wind offshore business around the world, and the recognized potential of the Brazilian offshore wind power, are encouraging players to initiate projects, preliminary studies, and partnerships in the country.

Another good reason of such enthusiasm is that Brazil has about 7,367 km of coastline, with a long continental shelf with very shallow waters. While the available water depths in Europe are not friendly anymore for bottom fixed turbines, Brazil is a virgin paradise, with huge opportunities for bottom fixed wind farms for many years.

²⁸ <https://www.conjur.com.br/2022-fev-06/publico-pragmaticotecnologia-eolica-offshore-decreto-109462022-consensualismo>



The recognized expertise in infrastructure construction, installation, operation and maintenance of oil and gas offshore assets in shallow, deep and ultra-deep waters, is considered an important facilitator of the wind offshore business in the country.

The green hydrogen business, another potential market under development in the country, will demand large amounts of dedicated green energy, and it is being treated as an important anchor for the wind offshore business in the future.

Last but not the least, the Brazilian government is mobilizing for the approval of the regulatory framework and also for a call for an exclusive offshore wind energy auction in 2023.

Yes, the moment is positive. But the offshore wind industry will still face significant challenges. Though Brazil has a regulatory framework development process moving relatively fast, there are many regulatory issues to be defined. Additionally, there is an existing infrastructure that needs to be adapted, and a domestic onshore supply chain that needs to be upgraded to support the offshore wind needs. Not mentioning the transmission infrastructure that will also need to be dealt with.

Opportunities are there, as also many challenges. If someone bet in 2010 that Brazil would be one of the major wind energy producers in the world, many people would not believe it. But it was a true reality less than a decade later. The same with solar energy. Would it be the same with offshore wind energy and green hydrogen energy? Probabilities are a strong positive answer for these questions.



9. MOST IMPORTANT ASSOCIATIONS

9.1 WIND POWER (ONSHORE AND OFFSHORE)

ABEEOLICA - Brazilian Onshore and Offshore Wind Association

Av. Paulista - 1337, 5 andar, SI51

CEP: 01311-200 São Paulo - SP

Tel: +55 (11) 3674-1100

faleconosco@abeeolica.org.br - selma@abeeolica.org.br

<https://abeeolica.org.br/>

9.2 SOLAR ENERGY

ABSOLAR - Brazilian Association of Photovoltaic Solar Energy

Tel:+55 (11) 3197-4560

Cel/whatsapp: +55 (11) 98943-4499

absolar@absolar.org.br

<https://www.absolar.org.br/en/>



10. MOST IMPORTANT FAIRS

BRAZIL WIND POWER

Venue: São Paulo Expo

12-14 September 2023

São Paulo - SP

<https://www.brazilwindpower.com.br/en/home.html>

INTERSOLAR

Venue: Expo Center Norte

29-31 August 2023

São Paulo – SP

<https://www.intersolar.net.br/home>

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