



WIND PROJECTS ON BRAZILIAN ENERGY AUCTIONS

*Evolution of registered projects
and their technical characteristics.
2018-2019 auctions update*

March, 2020



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Public company, linked to Ministry of Mines and Energy, set up by Law No. 10,847, of March 15, 2004, EPE is aimed in providing services in the area of studies and research to support the planning of the energy sector, such as electricity, oil and natural gas and its derivatives, coal, renewable energy sources and energy efficiency, among others.

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EXECUTIVE SUMMARY

This Technical Note presents a picture of the power generation projects from the wind source registered on EPE for several Energy Auctions in which wind farms have been able to participate with emphasis on the most recent auctions.

It seeks to register the developments over the 13 years in which EPE has carried out the technical qualification process of these projects (from 2007 to 2019).

Among the characteristics observed in the wind projects that have been registered for the auctions some numbers stands out:

- More than 800 anemometric stations have been installed to assess wind resources and more than 50 of them are new ones (first time in 2019) with 3 years (or more) of consecutive measurements;
- The average diameter of wind turbines went from 66 meters in 2007 to 128 meters in recent projects;
- Between 2018 and 2019, 3,456 projects were registered considering the four auctions held in the period;
- In these last four auctions, 650 MW_{mean} were traded and the prices were always below R\$ 100/MWh;
- The registration record number of 954 wind projects for a single auction (A-4/2017) was almost beaten in 2018, in which 931 wind farms were registered in Auction A-4/2018 and 929 in Auction A-6/2018;
- More than 600 wind farms have been built resulting in 15.4 GW of installed capacity.

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1 Introduction

The wind source has obtained an expressive participation in the Brazilian electric matrix representing 9% of the installed capacity in 2019. Nowadays it is the third source in terms of installed capacity and the second among the renewable ones. By 2029, the wind source is expected to reach 17% of the electric matrix by achieving 39.5 GW of installed capacity (EPE, 2019).

From the total capacity contracted in new energy auctions in 2019, approximately 34% (1,135 MW) came from wind power plants. With more than 15 GW already installed and 4.6 GW additional contracted, Brazil already represents the 7th largest market for onshore installations in the world. As a reference, in 2018 it was the 5th country in terms of number of new installations (GWEC, 2018).

Since 2007, when this kind of source started participating in the Regulated Market (ACR in Portuguese) energy auctions, several advances have been observed in the projects. This Technical Note aims to present an update on the evolution of wind power projects that were registered to participate in the energy auctions held in 2018 (A-6) and 2019 (A-4 and A-6).

It is also an extension of the 2018 document (EPE-DEE-NT-041_2018-r0¹), which showed the evolution of data from registered projects in the 12 previous years in which EPE carried out the process of technical qualification of wind farms for participation in the energy auctions.

As in the previous Technical Note, this new one addresses topics related to the growth in the number of projects, changes in requirements for technical qualification, changes in equipment designing, and the consequent impact on energy production. It also emphasizes the technological developments observed in the most recent projects.

Questions related to the schedule, investment costs, and energy price for the wind source are also addressed, where specific developments observed in the projects of previous auctions are highlighted.

¹ Available only in Portuguese in <http://bit.ly/EOL12anos>

2 Auction Submission and Technical Acceptance

2.1 Registration of Projects

The submission and technical qualification of projects are carried out by EPE in accordance with the MME guidelines and follow the principles of MME Ordinance nº102/2016 and the EPE Instructions Document (*"Instruções para Solicitação de Cadastramento e Habilitação Técnica com vistas à participação nos Leilões de Energia Elétrica"*, available in Portuguese).

Figure 1 shows, in a comparative way, the amount (in MW) of registered projects from each source per year. It also shows the increasing participation of the wind source over time: starting in 2007, with less than 10% of the total number of projects, reaching its peak in 2013 with more than 60% of the registered projects. From 2014 to 2018, the number of projects varied between 40% and 50% of the total registration. In 2019, however, it reduced to 33% of the total registration.

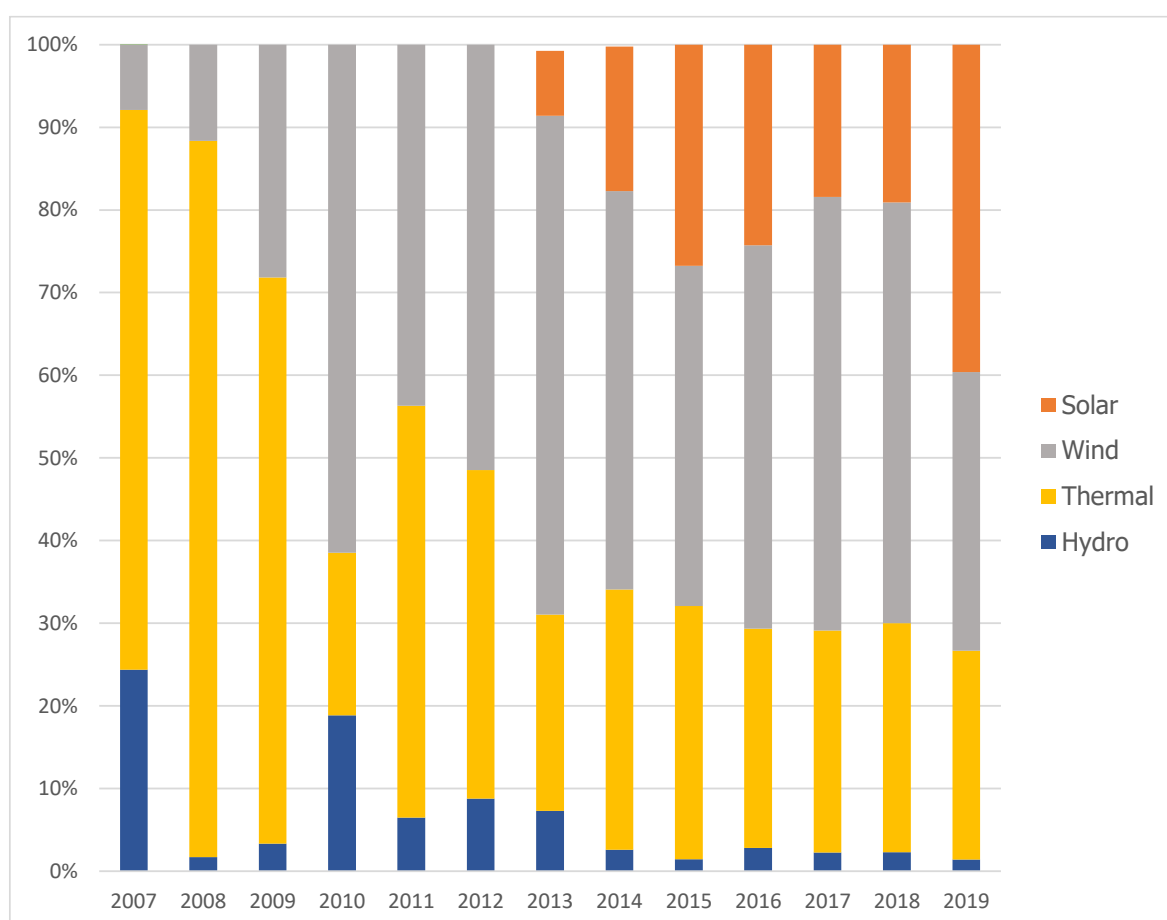


Figure 1 - Participation of each source in the auctions - registered projects capacity share

The MME guidelines define which sources can participate in each auction. Thus, when the Alternative Energy Sources or the Reserve Energy Auctions were held,

there was a greater share of wind source participation since these types of auctions generally favor renewables.

Figure 2 shows the total registered installed capacity of wind projects in each region considering the auctions held between 2007 and 2019. The Northeast region of Brazil has a significant number of submitted projects and, consequently, a higher share of the total installed capacity.

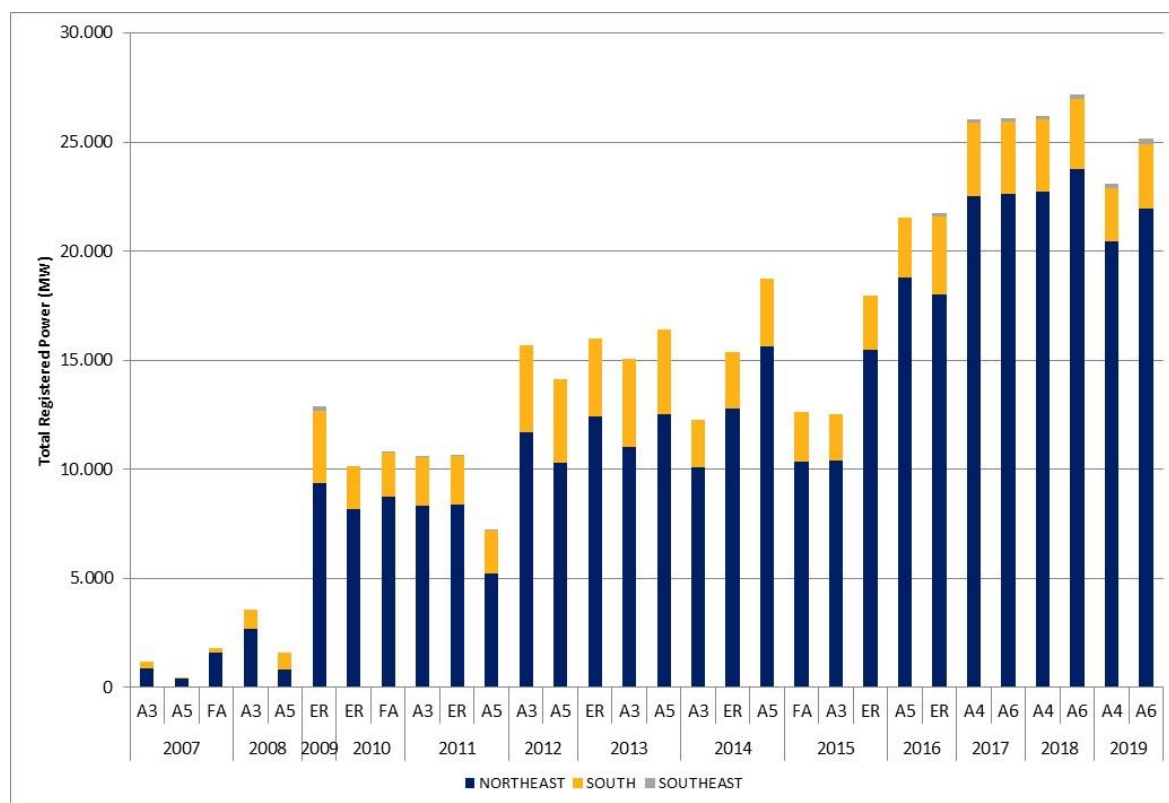


Figure 2 - Wind farms - total registered capacity (MW) by region, auction, and year

Figures 3 to 5 show the number of registered wind projects in each state and region considering all the auctions in which wind source was allowed to be registered. In this period, the states of Bahia, Rio Grande do Norte, and Rio Grande do Sul present the largest number of registered projects.

It is important to mention that the Southeast region still has a small number of projects when compared to the Northeast and South regions.

It should be noted that the same project can be registered for successive auctions and, therefore, the numbers in the figures may count a single project more than once.

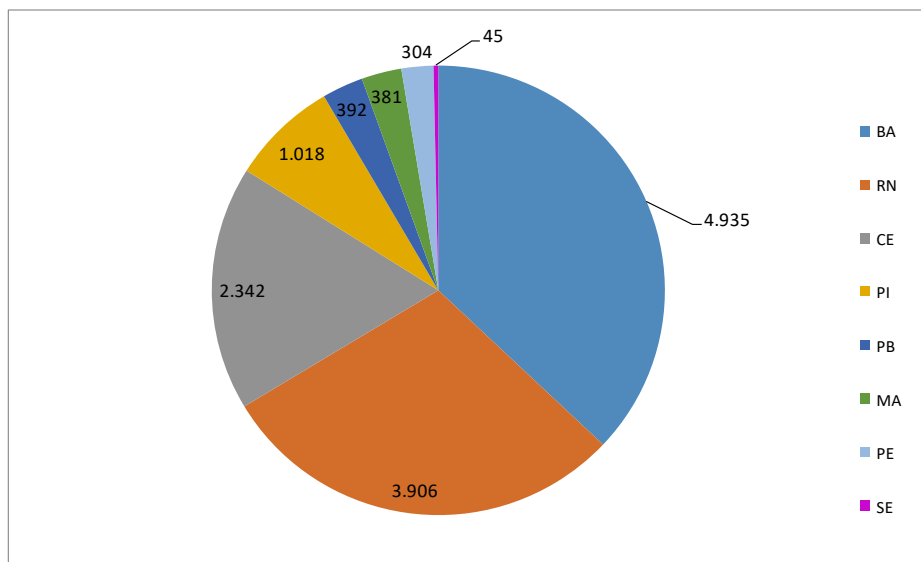


Figure 3 - Total of registered projects in the Northeast region

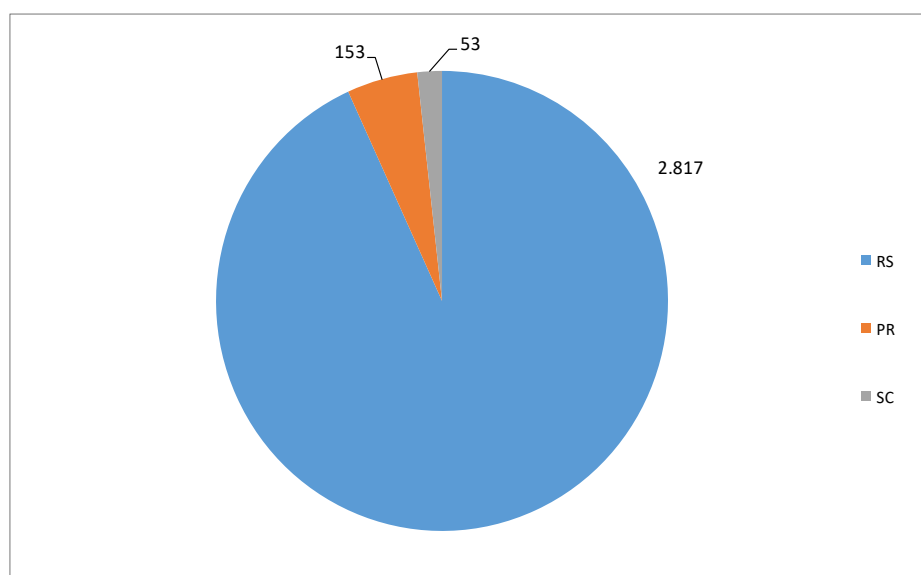


Figure 4 - Total of registered projects in the South region

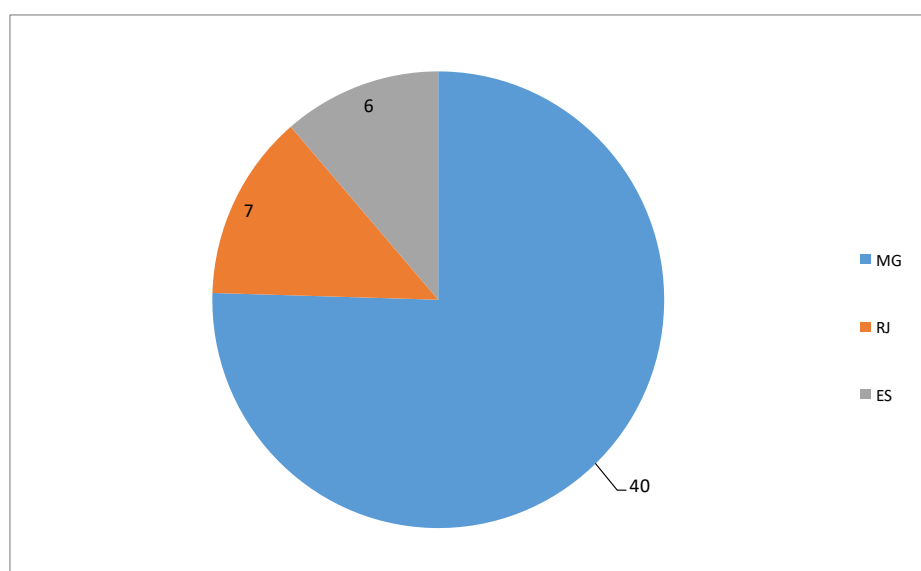


Figure 5 - Total of registered projects in the Southeast region

2.2 Technical Qualification

The technical qualification process aims to analyze the registered projects in order to certify that they fulfill the minimum technical requirements specified for participation in the auctions. These requirements are important to mitigate the risk of contracting projects that are unable to deliver the amount of purchased energy.

Figure 6 shows the evolution of the number of registered wind projects distinguishing the technically qualified from the disqualified ones.

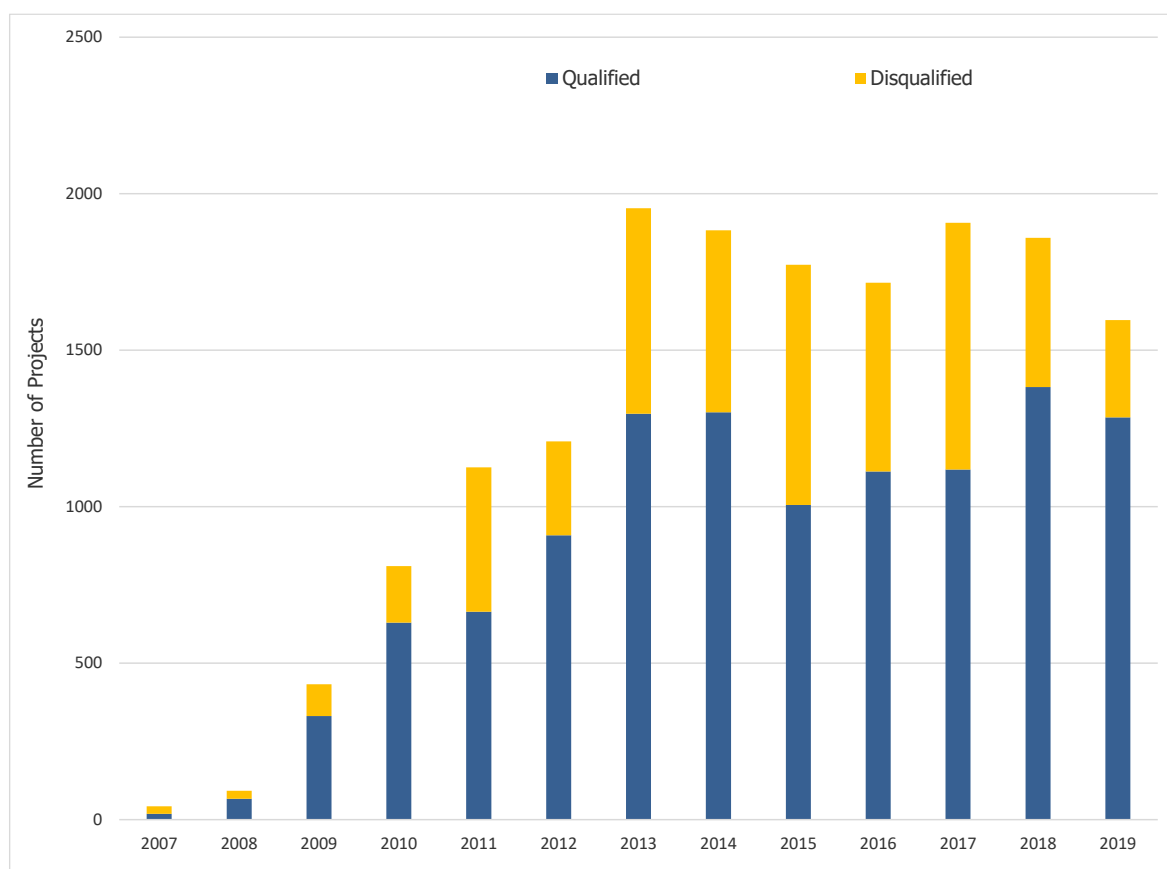


Figure 6 - Total of wind projects analyzed in each year

On average terms, more than 60% of registered wind projects were qualified by EPE. In 2019, the disqualification did not exceed 20%. The main reasons for disqualifying are shown in Figure 7. Note that the same project may be disqualified in the same auction for different reasons.

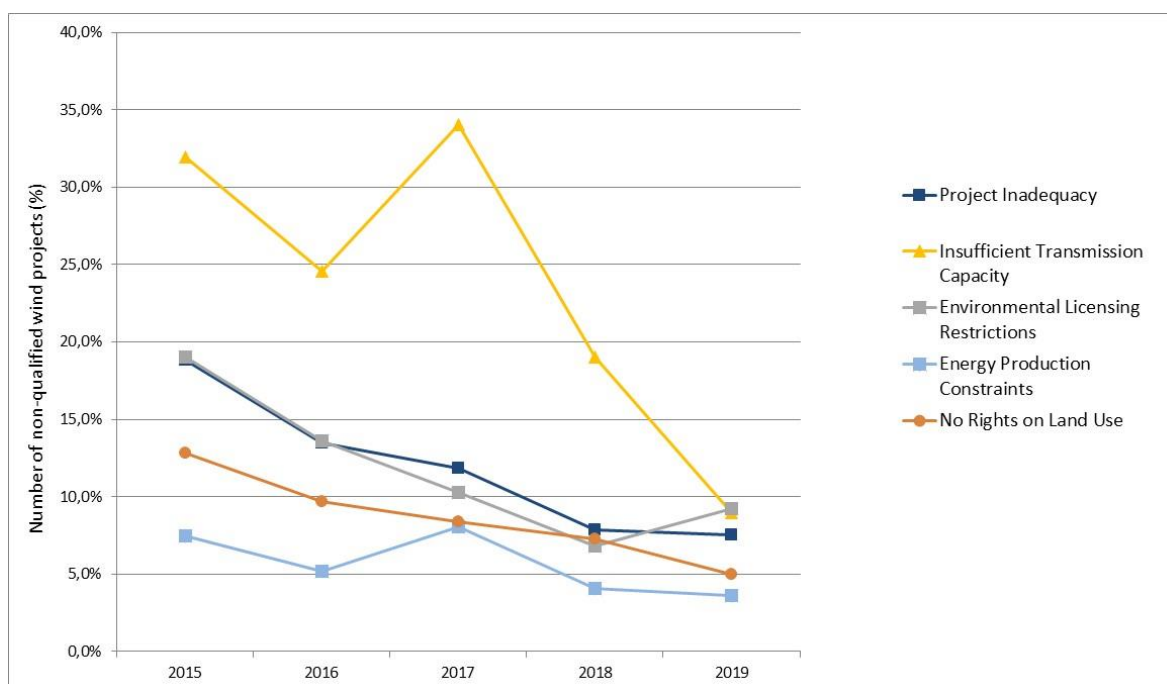


Figure 7 - Details of the reasons for disqualifying, by year

Figure 8 details the different reasons for disqualifying the projects considering the states with higher number of projects (Bahia, Rio Grande do Norte and Rio Grande do Sul) for the 2018-2019 period.

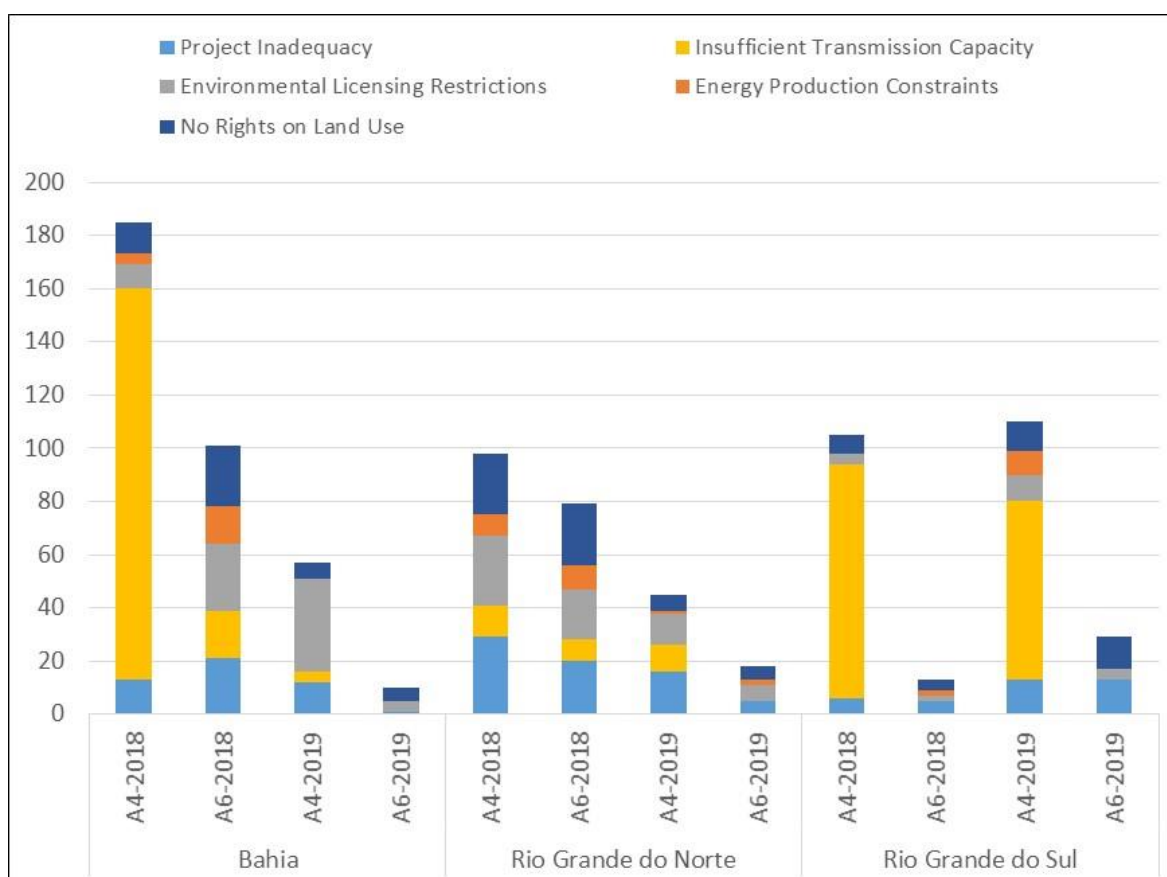


Figure 8 - Number of non-qualified wind projects in the states of the federation with the highest participation detailing the disqualifying reasons

The number of projects disqualified due to **insufficient transmission capacity** has fallen substantially on the auctions held in 2019 due to the conclusion of transmission system expansions that have been recommended in EPE's planning studies. Considering the new transmission lines and Main Grid substations that will be installed within the energy auctions analysis horizon, it is possible offer a larger transmission capacity due to the increase in the flexibility and the reliability of the transmission system.

In the auctions held in 2018, however, it is possible to notice that the states of Bahia and Rio Grande do Sul were the ones which had the greatest numbers of disqualified projects due to Insufficient Transmission Capacity.

Two different Technical Notes related to the transmission system capacity assessment were published according the requirements established by the MME Ordinance nº 444/2016. The first Technical Note is a document that was published by both EPE and ONS (EPE-DEE-RE-021/2019 - ONS NT 0039/2019) in May 2019. This Technical Note presented the methodology, the main assumptions, and the technical criteria used in the process of obtaining the remaining system capacity values for all registered points of connection for the generation projects.

The second Technical Note was published by the ONS and it contains the transmission system capacity values calculated in accordance with the guidelines established in the first Technical Note.

It is also important to mention that the Ordinance nº 444/2016 is a fundamental document for the process of computing the transmission system capacity values. Not only does it allow a standardization of the process by defining the main guidelines for obtaining the system capacities, but it also turns the process more transparent, predictable, and it allows the entrepreneurs to make similar assessments on their own.

In the A-6 Auction, EPE is responsible for the assessment of the connection conditions for all points of connection that are registered in the Auction (except for points of connection classified as Distribution Installations). During these assessments EPE takes into consideration the following information: (i) the transmission system expansions that have been recommended in the previous planning studies; (ii) the previous planning studies that have established the most suitable points of connection for generation projects; (iii) the previous generation auction results as well as projects that have made energy contracts in the spot market and that have signed connection contracts with the ONS.

At the end of the connection assessment process EPE publishes a specific document that contains the results of the connection condition analyses. If no serious restrictions are observed then the project can be qualified for the energy auction.

The benefits of the planned transmission expansion were more clearly observed on the A-4/2019 auction. The Technical Note ONS-NT-0046/2019² published by the System Operator shows the transmission system capacities for each registered point of connection. The main results of that Note show that there were very few restrictions to the connection of projects that have participated on the auction. Naturally, the increase in the system capacity was also noticed on the technical analysis made by EPE for the A-6/2019.

Related to the **environmental licensing** documentation of the A-4/2018 projects it is possible to mention that there were 33 disqualified projects. From this quantity, 10 did not send the environmental license, and 23 presented an incompatible document. On the A-6/2018 auction, there were 26 disqualified projects. From this quantity, 17 did not present the Environmental License, 8 had inconsistencies between the license and the submitted characteristics for the project, and 1 presented an expired license.

On the A-4/2019 Auction, there were 71 (9.77%) disqualified projects. That represented an increase in numbers when compared to the A-4/2018. From this quantity, 29 were not qualified due to incompatibility between the license and the submitted characteristics for the project, 21 for had submitted an expired license, and 21 did not submit any licensing document at all.

Finally, on the A-6/2019 Auction, there were 30 (3.78%) disqualified projects. From this quantity, 16 submitted expired environmental license, 13 did not submit the environmental license, and 1 was disqualified due to incompatibility between the license and the submitted characteristics for the project.

Taking into consideration the environmental analysis of the four auctions, it is possible to see that the main reason for project disqualification was the absence of Environmental Licensing and the incompatibility between the license and the data of the registered projects. Considering the progress of the environmental licensing process, the projects that did not have a license have a tendency to do so in future auctions and those with incompatible information tend to adjust the data.

The CONAMA Resolution nº 462, published in July 24, 2014, establishes the procedures for environmental licensing of onshore wind energy projects and details

² Available only in Portuguese at: <http://epe.gov.br/pt/leiloes-de-energia/leiloes/leilao-de-energia-nova-a-4-2019>

the guidelines for environmental assessment, including the information that should be listed on the licenses and authorizations.

Regarding **land use rights**, it is not possible to identify a specific requirement, among the ones in EPE's Instructions, that has led to greater difficulties for the entrepreneurs to comply with.

Actually, the disqualifications of wind projects in 2019 energy auctions were due to different reasons such as lack of an agreement contract between the entrepreneur and the landlord and lack of the agreement contract or the geospace terrain data register on the land documents.

Thus, it is not possible to point out a particular requirement that has led to difficulties in proving the land use rights of wind projects.

3 Results and Evaluations

3.1 Wind Resource Analysis

This topic presents wind resource analysis based on certified data from technically qualified projects. When submitting a project, developers must include a Certification of Wind Assessment and Energy Production Estimate prepared by independent entities with proven experience. This documents should assess the estimated annual production of the wind farm and its uncertainties based on the characteristics of the projects and wind measurements at the wind farm location.

More detailed information on wind resources such as speed seasonality by state, measurement heights, and examples of speed histogram and wind rose diagrams were presented in the Technical Note EPE-DEE-NT-041/2018-r0.

For the technical qualification of projects, at least 36 consecutive months of on-site wind measurements are required according to art. 6, II, of MME Ordinance nº102/2016. In the first auctions, local measurements were not mandatory. However, it was required for the first time in 2009, for a minimum period of 12 consecutive months. Subsequently, it was increased to 24 months in 2011 and to 36 months from 2017 on.

Figure 9 shows the measurement time of the qualified projects indicating that in 2019 most of them had data measurements for a longer time than the minimum required. As many entrepreneurs reuse the documents of previously registered projects (it was allowed in 2019), the certifications may not consider recent measurements. Thus, if the certifications were redone in 2019, the measurement periods would probably be even longer.

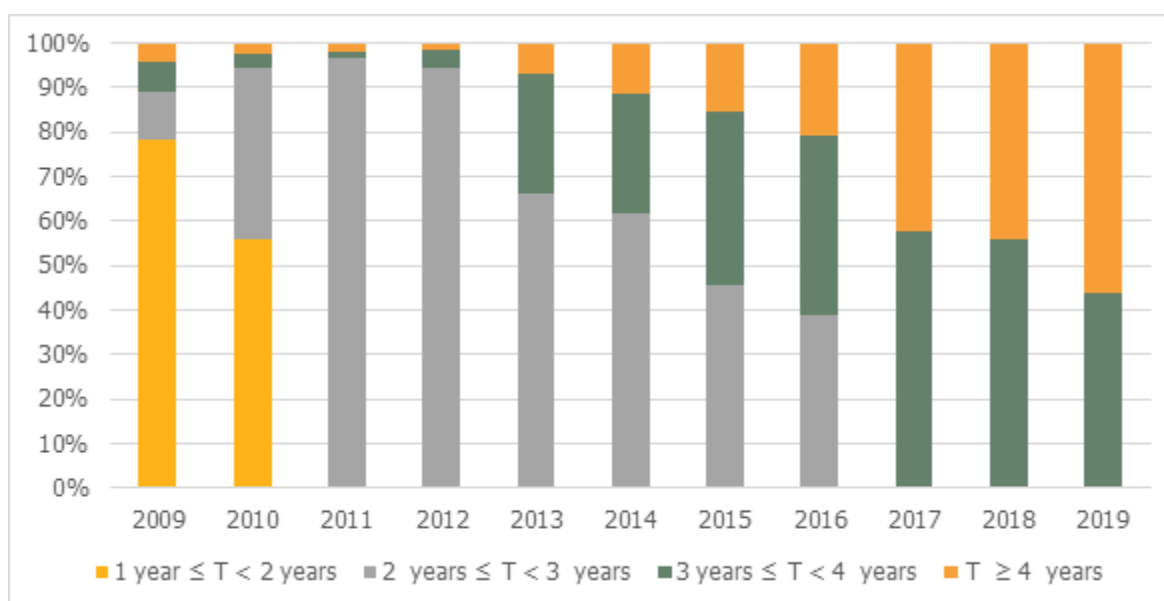


Figure 9- Share of qualified projects detailed by measured period for each year

The locations of met masts for wind resource assessment are shown in Figure 10 considering projects qualified between 2009 and 2019. The most recent ones, which were not used in previous auctions are highlighted on the map as new anemometric stations. The increasing participation of the wind source in the auctions resulted in more than 800 met masts installed.

It is worth mentioning that the average wind speed data (at 100 meters height) layer on the map was generated from the reevaluation of the Brazilian Wind Energy Atlas (CEPEL, 2001) using a new roughness map produced by the National Institute for Space Research - INPE.

It is important to note that according to current rules, a met mast can be shared by several projects within ten kilometers from the station in the case of flat surface terrains with homogeneous roughness and up to six kilometers in the case of complex terrains. Thus, all the wind turbines of the project must be installed within this limit.

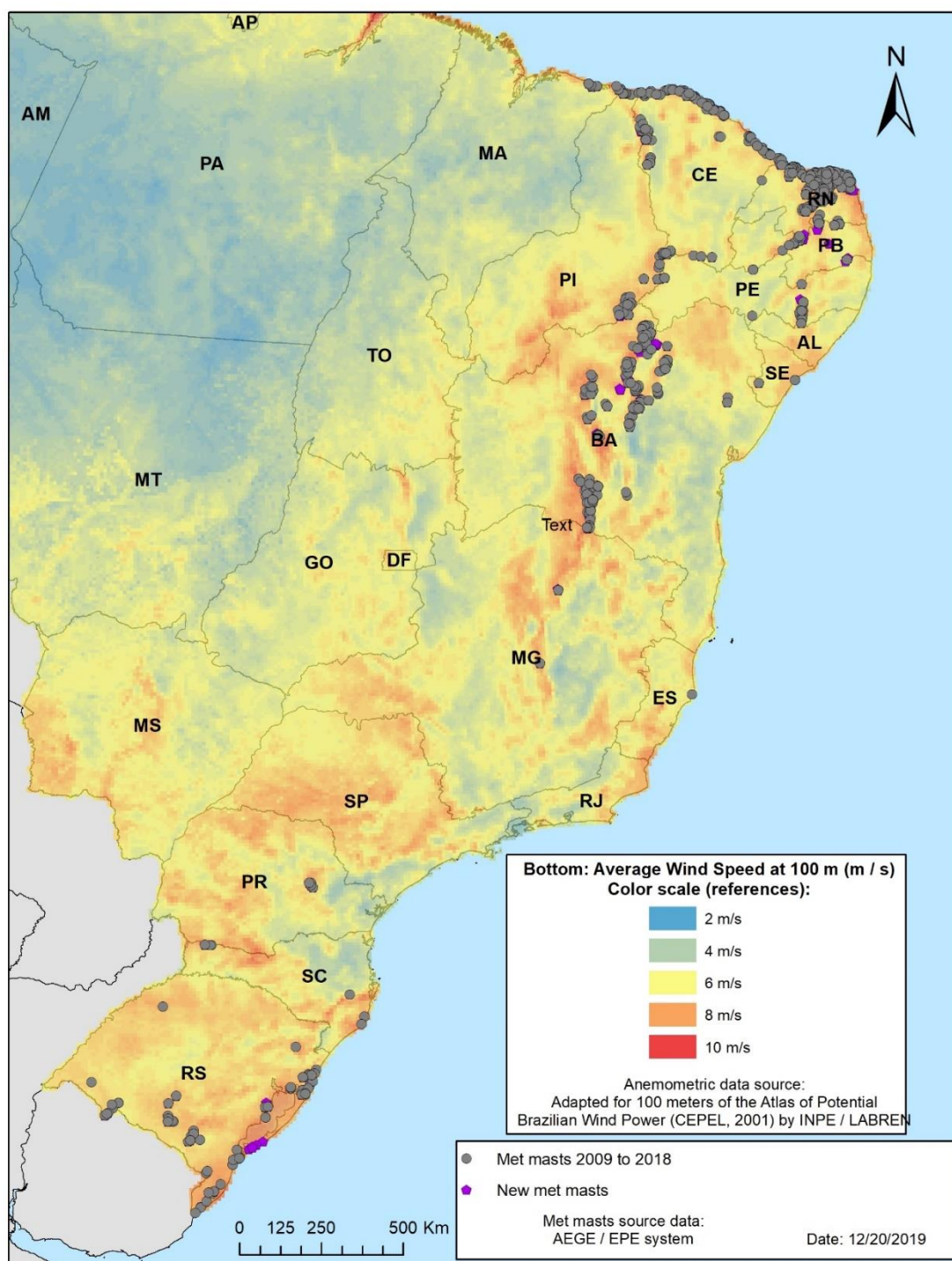


Figure 10 - Location of met masts for qualified projects from 2009 to 2019

3.2 Uncertainty of Energy Production Estimate

The standard uncertainty of a wind farm corresponds to the standard deviation of the expected annual generation values for the duration of the contract and is the result of the composition of the various uncertainties (anemometric measurement,

data correlation and extrapolation, wake effect, turbine power curve, interannual variability, etc.).

The mean uncertainties regarding energy production are shown in Figure 11 for the qualified projects in each year. A gradual reduction of values over time can be noticed and it can be explained by the quality improvement and longer anemometric measurements, which results in greater reliability of the wind resource estimate and of the energy production estimate. In fact, the standard uncertainty in the wind speed is amplified by a factor of the order of 2 when converted into standard energy production uncertainty. The behavior of the data did not change significantly between 2018 and 2019.

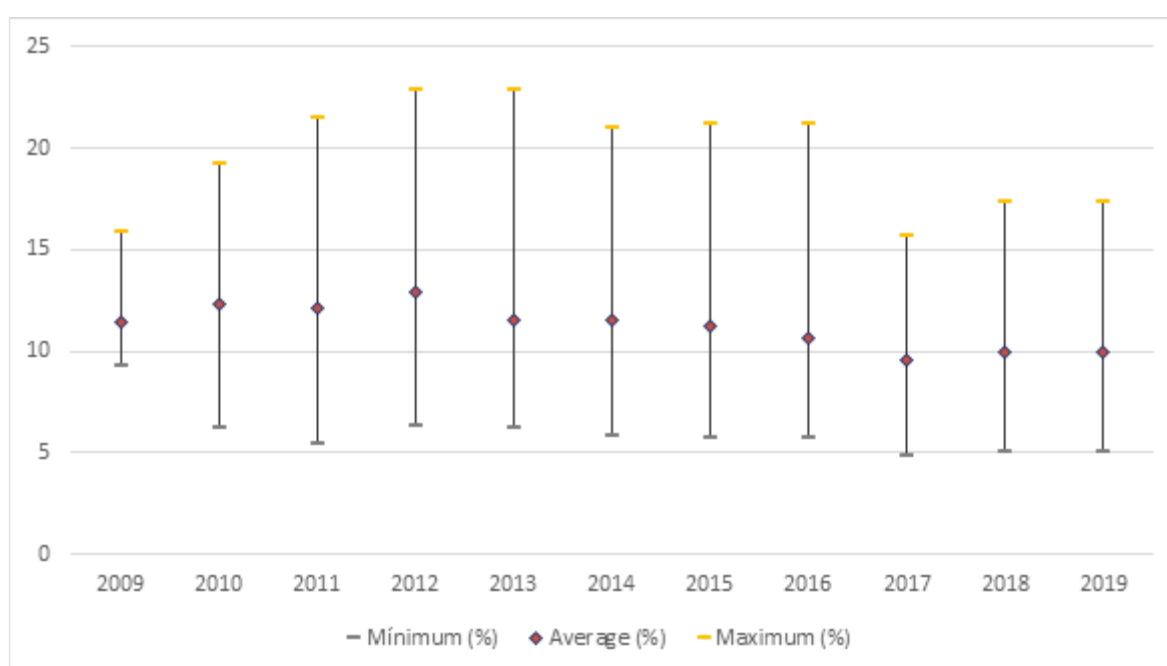


Figure 11 - Minimum, average and maximum of the standard uncertainties of the qualified projects per year

3.3 Equipment

As indicated in the report EPE-DEE-NT-041/2018-r0, the most important technical characteristics for wind turbine size are: rotor diameter, hub height (length from the ground to center line of turbine shaft) and unit power. The energy production of a wind farm is estimated from the definition of these parameters taking into account the wind resource of the place where the equipment will be installed.

Thereby, the graphs bellow shows the evolution of these parameters referring to qualified projects, in which a constant progression is noted.

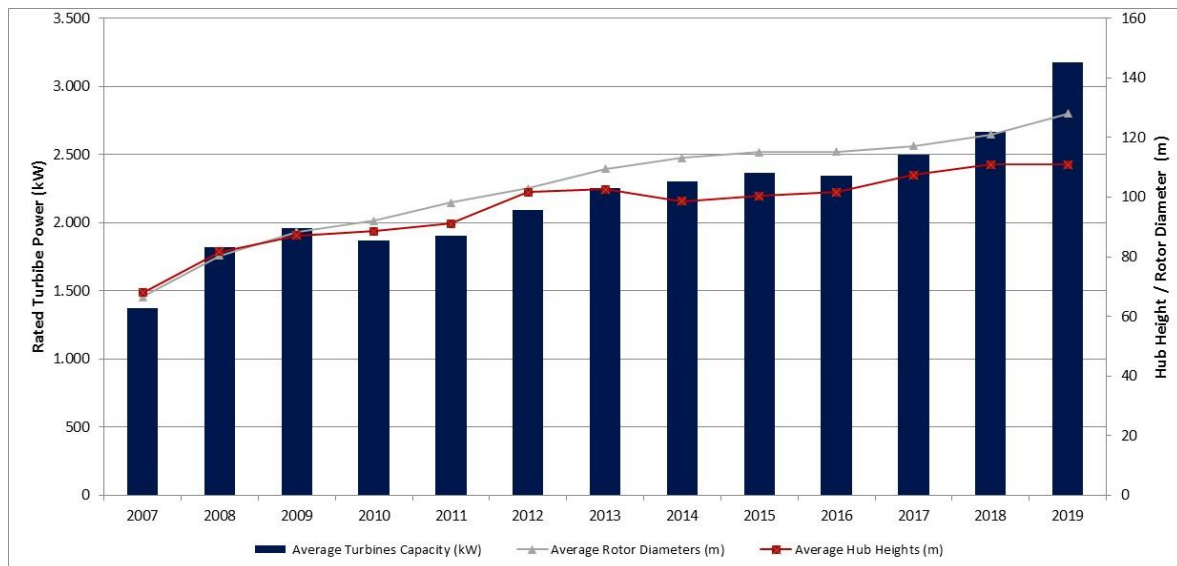


Figure 12- Average turbines capacity, rotor diameters and hub heights

The increase in wind turbine diameters in the 2018 and 2019 qualified projects followed the evolution of the equipment with higher rated power.

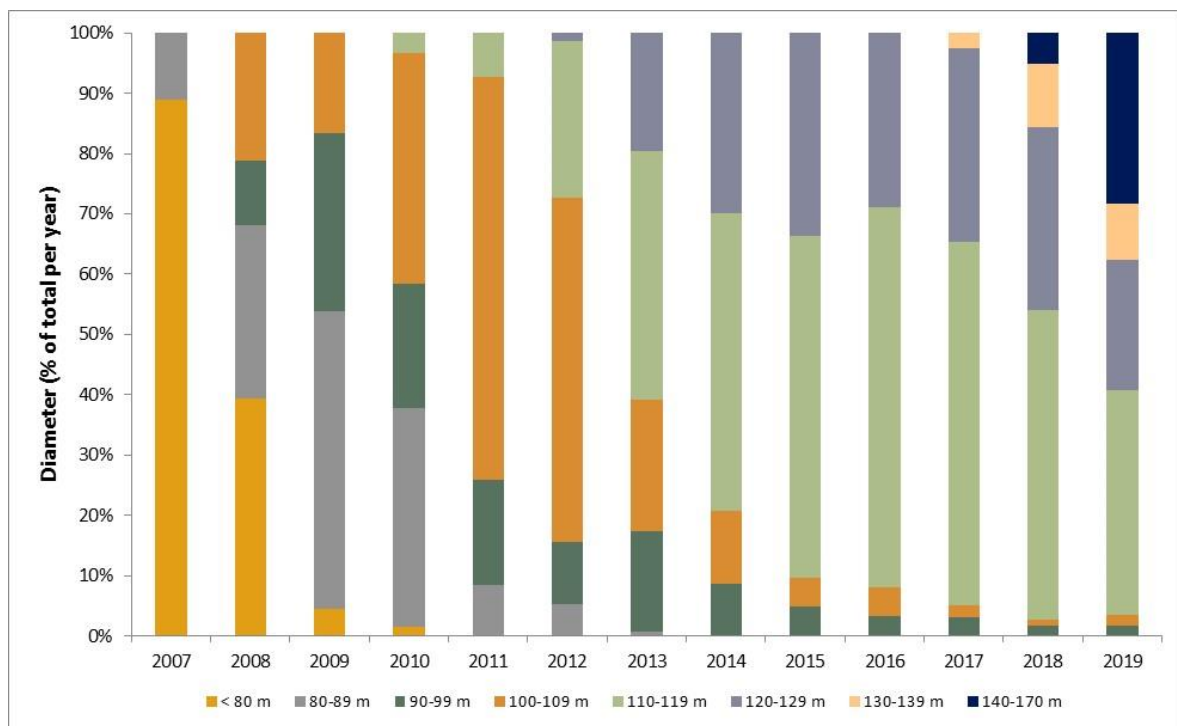


Figure 13 – Evolution of rotor diameters

Part of the wind turbines from projects qualified for the 2019 auctions already have diameters varying from 140 meters to 170 meters (28%) and hub height above 120 meters (59%).

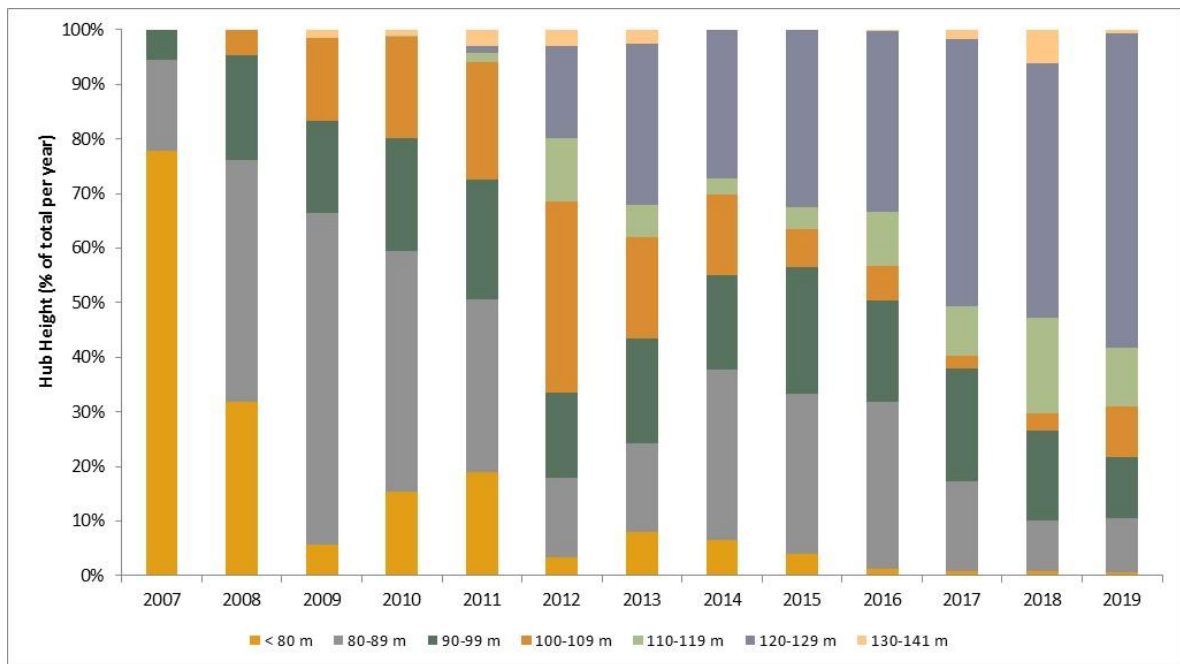


Figure 14 – Evolution of hub height

Between 2017 and 2019, the analysis of these three parameters reveals a tendency of stabilization of the hub heights (between 120 and 129 meters) and rotors with diameters varying from 140 to 170 meters, which allows an optimization of wind resource use at the same hub height. This way, it is possible to increase its average rated power and optimize the construction and assembly of wind farms.

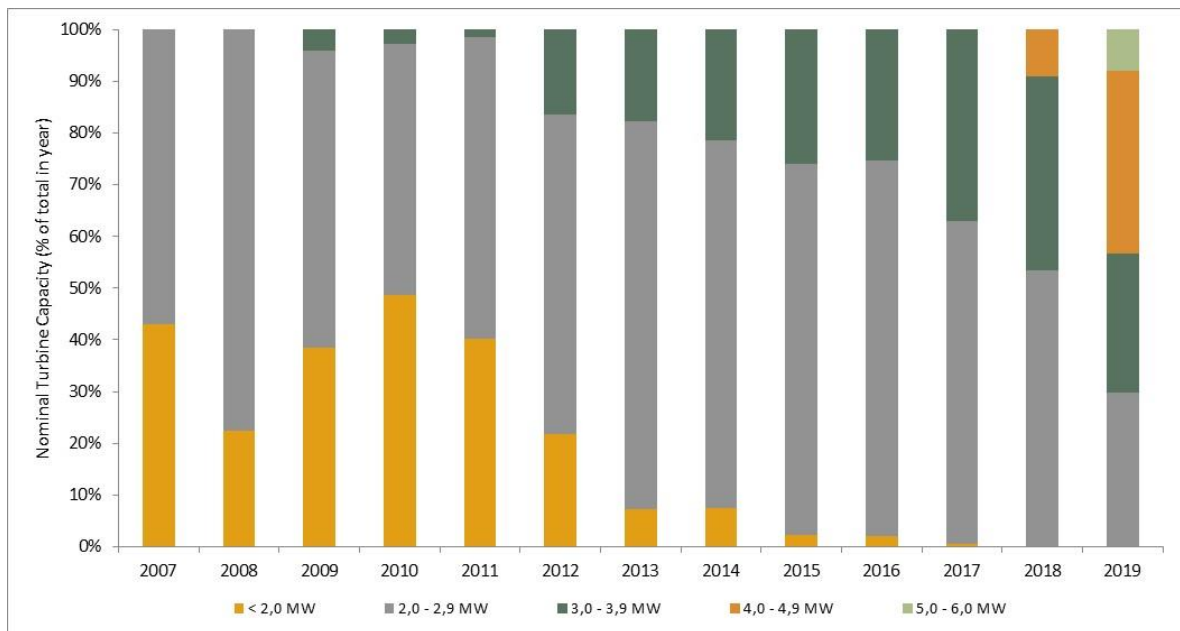


Figure 15 - Evolution of nominal capacity of wind turbines

In the 2019 auctions 43% of the turbines from the qualified projects had nominal capacity between 4.0 MW and 6.0 MW. The average rated capacity of the turbines increased from 1,375 MW, in 2007, to 3,177 MW, in 2019, a growth of 131%.

3.4 Capacity Factor

The capacity factor is defined as the ratio between the electrical energy produced by a power plant and the energy that could have been produced at continuous full power operation during the same period.

The evolution of wind turbines has led to an increase in the capacity factor. In addition to the technical characteristics of the wind turbines, the high availability of wind resource in the regions with the greatest number of projects contributes to the high capacity factors.

It should be noted that the energy production of a wind farm can be estimated from different metrics: based on the P50³, P90⁴ or on the firm energy certificate. Figure 16 shows the evolution of the average capacity factors based on the P50 declared by the entrepreneurs and on the firm energy certificate of the qualified projects each year. As can be seen, the capacity factor curve based on the firm energy certificate shows a sharp drop in 2013, when the methodology for calculating these certificates was changed. Until then, it was based on the P50 and it was later changed to the P90.

The curve based on the P50 shows that the increase in the average capacity factors has been greater between 2008 and 2013 and that from 2015 on, the values remained in similar levels. This trend has remained in recent auctions.

³ Expected energy production of the power plant with 50% or higher probability

⁴ Expected energy production of the power plant with 90% or higher probability, calculated from P50 value and standard uncertainty, assuming a normal distribution

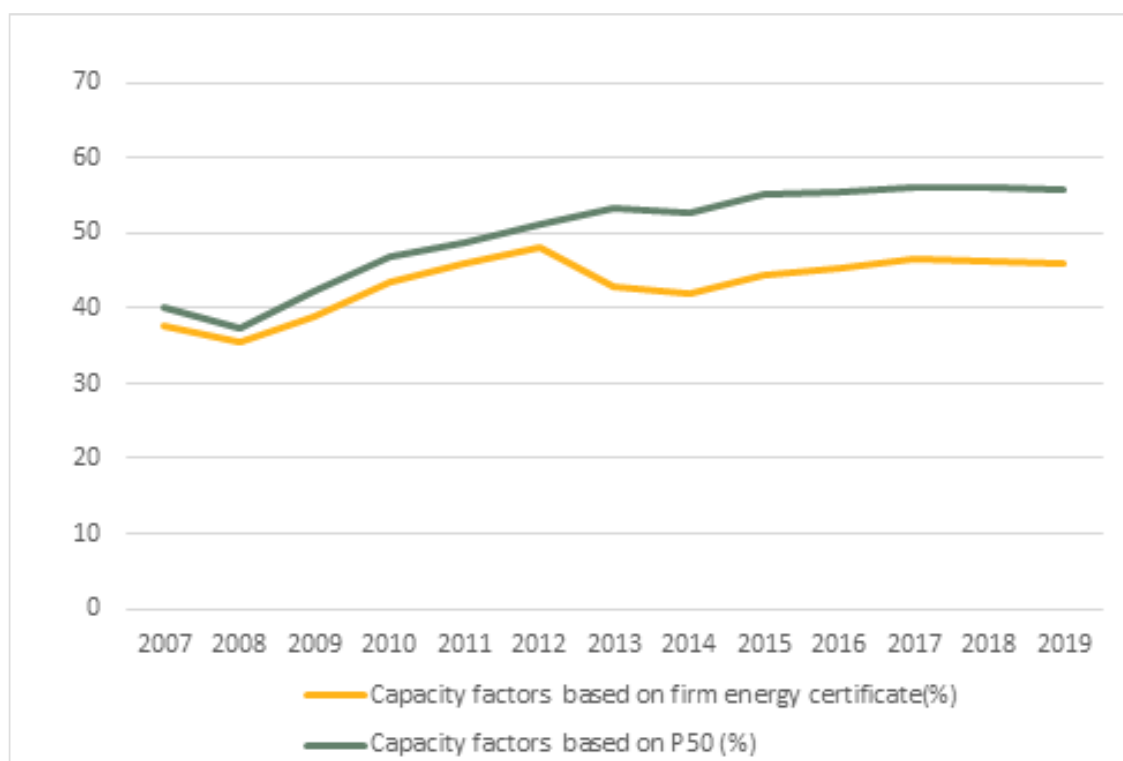


Figure 16 - Average capacity factors, based on P50 and firm energy certificate

Figure 17 represents box diagrams for the capacity factors based on P50 using quartile and percentile statistical parameters. The blue boxes represent the interquartile range considering values of the capacity factors of 50% of the qualified projects in that year while the black bars include data from another 40% of the projects using the 5th and 95th percentiles. Thus, 5% of the projects with the highest values and 5% of the projects with the lowest values of capacity factor were excluded.

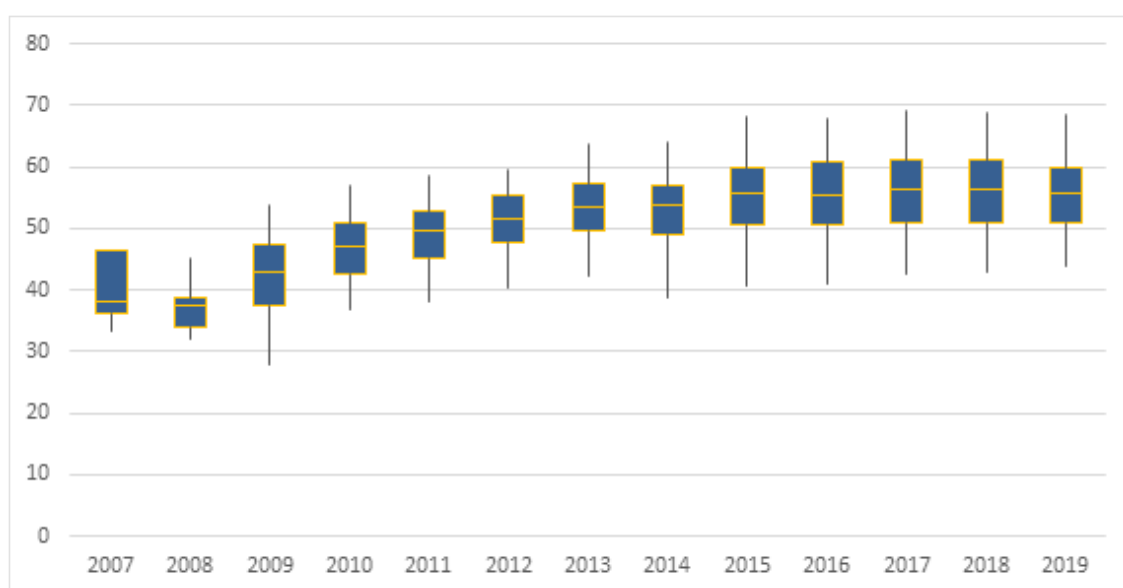


Figure 17 - Average capacity factors, based on P50

In 2019, more than half of the values were concentrated between 50% and 60%. The average capacity factors verified by the ONS (on the Monthly Operation Bulletin)

in recent years have been above 40% considering plants type I and II-B and the group of plants connected to the main grid.

The large number of met masts as well as the available measurement period have led to a greater knowledge about the wind characteristics at the project sites and they have allowed entrepreneurs to select machines suitable for each region and wind regime.

The contracting and remuneration model for wind farms used in energy auctions may also have contributed to the search for high capacity factors given that the firm energy certificate of the projects is the main parameter for defining the amount of energy to be negotiated. When using turbines with larger diameters for the same rated power in a park, there is a gain in energy production, which also increases the firm energy certificate. It compensates the higher cost of a larger turbine and increases the competitiveness in the auction.

The capacity factors of current projects are among the largest in the world. It is important to discuss the possible reasons. Regarding the size of the wind turbines, the technological developments, which occurred not only in Brazil, has allowed the increase in the diameter of the rotors and the height of the towers, contributing to greater capacity factors.

In 2019, although the average diameter of the wind turbines increased, the average rated power grew at an even higher rate leading to an increase in the mean specific power (in W/m^2) of the equipment as shown in Figure 18.

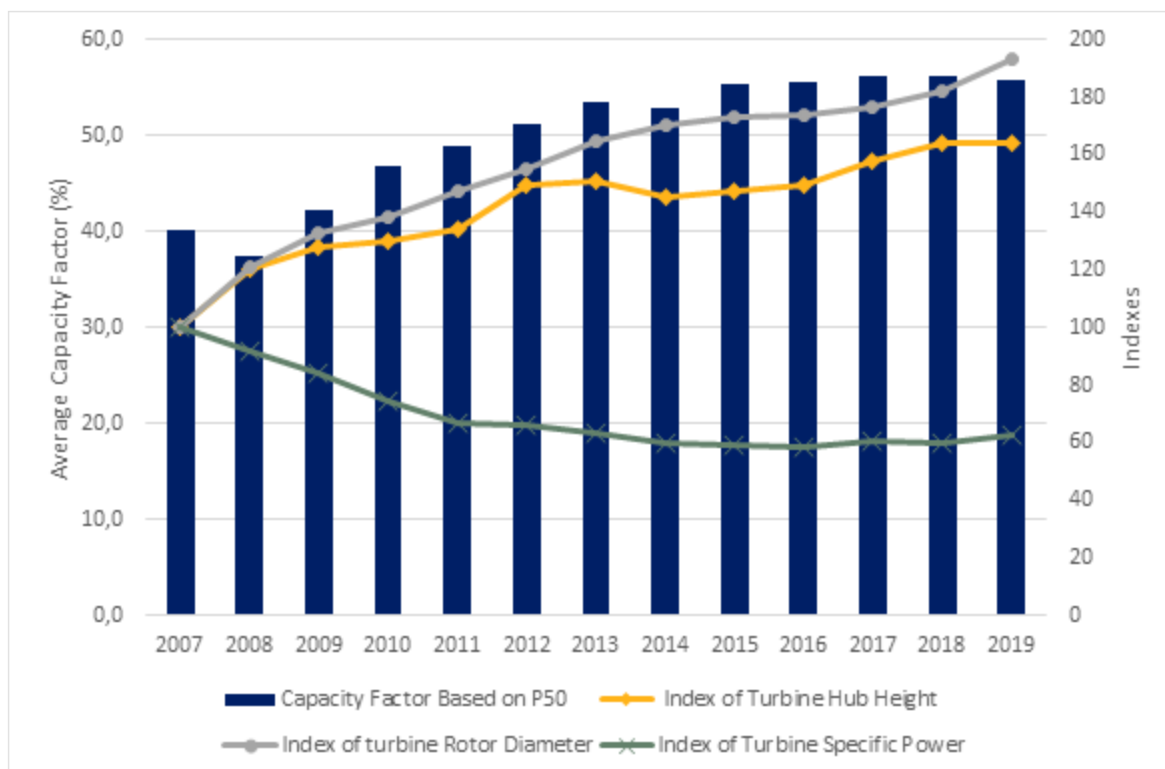


Figure 18 - Average capacity factors and indexes of turbine hub height, rotor diameter and specific power⁵

It is observed that, despite technological developments, the capacity factors have not increased significantly in the last 4 years.

3.5 Construction Time

Based on the schedules informed by the entrepreneurs between 2015 and 2019 on the AEGE system, it can be seen that the construction timeline in 2015 used to be 12 months, which is the shortest period recorded in these last 5 years. In the following years, these schedules were reevaluated considering the learning curve of construction and assembly of these projects.

As Figure 19 shows, in the 2018 and 2019 auctions, the average construction time rose again to 15 months according to both A-6 auctions.

These times refer to the start and end dates of work, not considering the time required to obtain environmental and regulatory licenses, financing, PPA sign, among other phases of the project as a whole.

⁵ In order to evaluate the influence of the height, diameter and specific power of the turbines on the capacity factor, the three parameters were represented in the form of an index that considers the respective 2007 value as 100 and the values for the other years are represented proportionately.

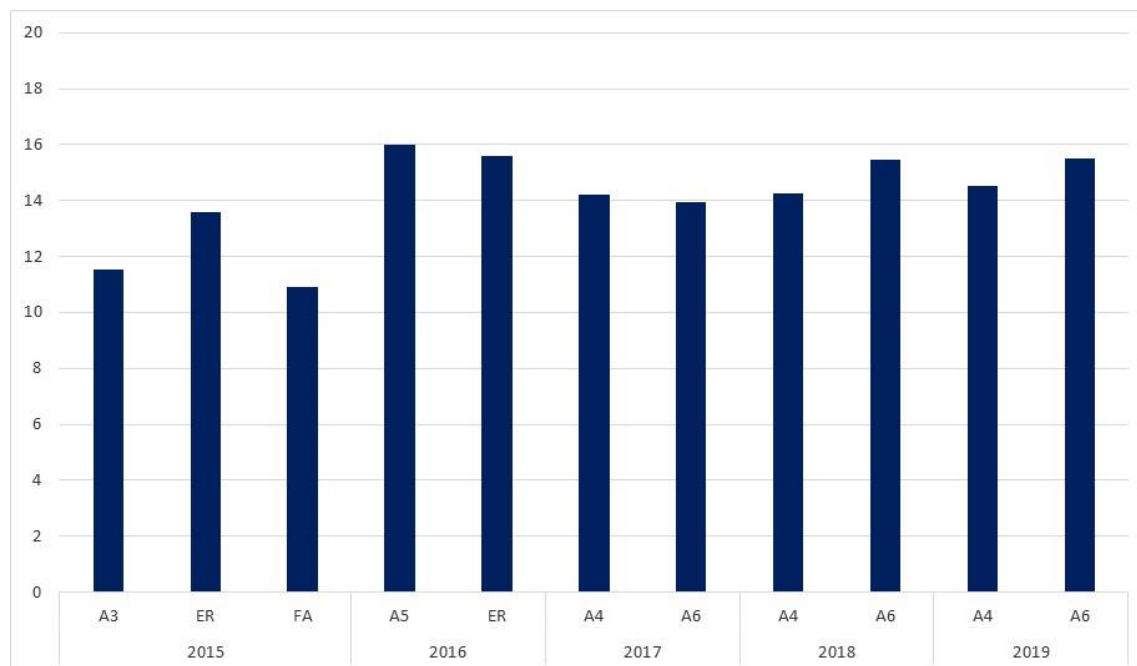


Figure 19 - Average time for building the wind farms (months)

The dimensions of the components of a wind turbine are very specific and a rotor blade can reach up to 80 meters length. Consequently, the logistics for transporting these blades are quite complex. Usually they leave the factories in special trailers and are taken to the nearest port and they are transported in ships to the port nearest to the place where the wind farm construction site. Then they are unloaded and sent by trucks to the construction site.

This happens in most parks installed on the South and Northeast coasts. However, in the case of projects located in the countryside, this logistics depends on the roads infrastructure both for blades and towers and also for other equipment of the wind turbines. This often takes additional six months compared to the parks on the coast based on the schedules of projects in Rio Grande do Sul state, as shown in figure 20.

It is worth mentioning that these are average times and they should be considered as merely indicative since each location has its own particularities such as access roads, land topography, etc.

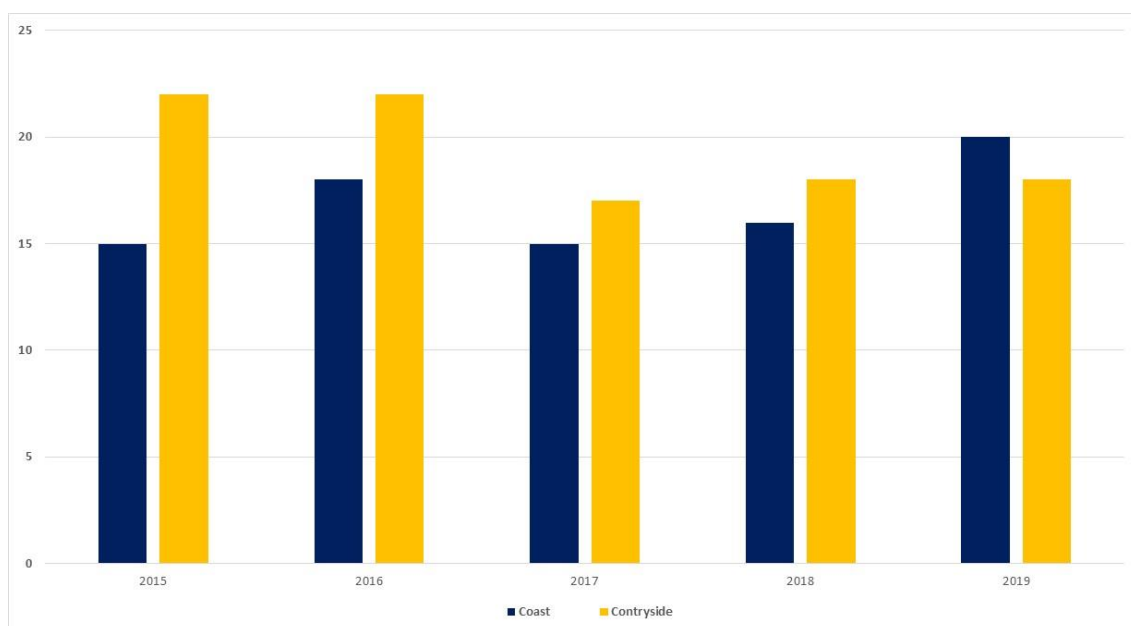


Figure 20 – Average implantation time of farms in RS (coast x countryside)

The selected sites for the construction of the wind farms are also subject to climatic conditions (high humidity, strong winds and heavy rainfall) during construction and these factors might interfere on the scheduled activities such as equipment lifting, electromechanical assembly, and civil structures concreting as well as factors related to the logistics. All of these factors may delay the progress of construction works.

3.6 Capital Expenditures (CAPEX)

When analyzing the CAPEX values declared in the qualified projects there is a 13% reduction approximately in the 2019 average (R\$ 5.066/kW, or U\$ 1.284/MW⁶) when compared to the 2018 mean values as shown in Figure 21 below. Such investment values are “overnight costs”, i.e., they do not consider interest rates during construction and they are originally referred to the month of December of the year before the auction. For the following analyses, the values have been updated to the same reference date (Oct/2019) considering the Brazilian inflation index (IGP-DI⁷) variation in the periods.

⁶ Exchange rate (average 2019) = R\$ 3,9445/US\$. Source: <http://www.ipeadata.gov.br>

⁷ Acronym of “General Price Index - Internal Availability” (Índice Geral de Preços - Disponibilidade Interna)

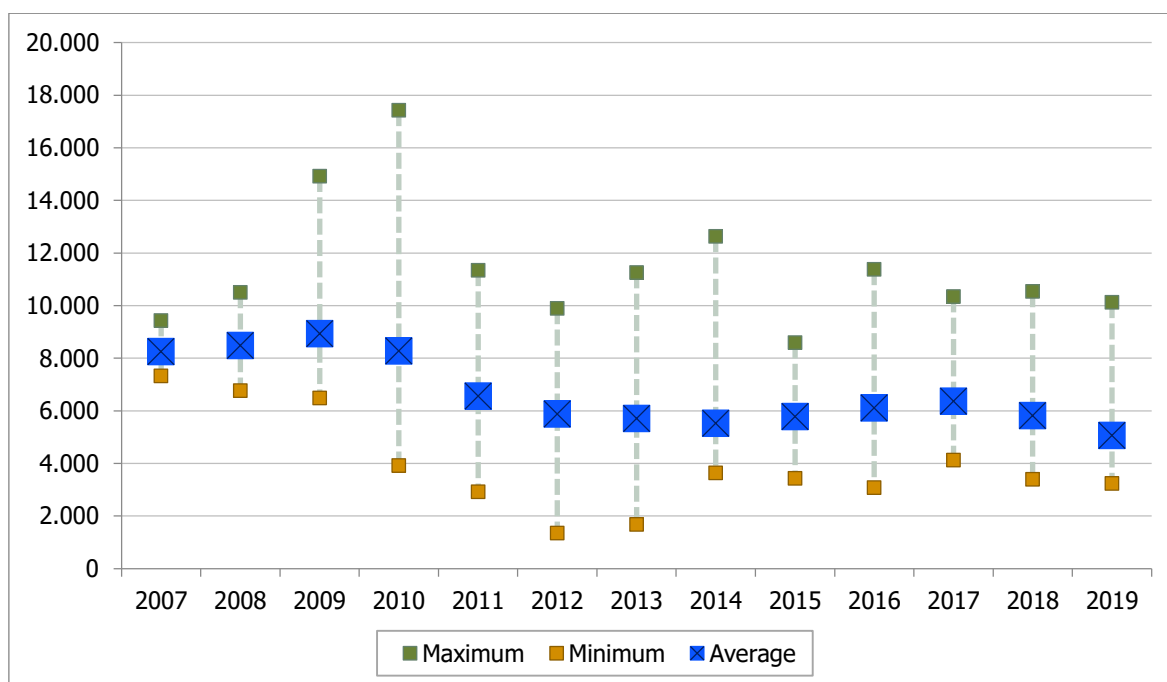


Figure 21 – Estimated CAPEX of qualified projects per year in R\$/kW

The maximum and minimum ranges of the declared values in the projects have remained similar in recent years. This behavior of the ranges can be interpreted as a consequence of the maturity of the wind source in the market with more consolidated costs.

In the sample of qualified projects of 2019, the representativeness of each cost in the share of total was also analyzed. As can be noted in the previous years, the equipment corresponds to most of these costs representing around 68% of the CAPEX, which means that the cost of wind turbines is a relevant factor for wind energy cost composition and they are a driver for cost reduction.

Comparing the average investment cost value of Brazilian projects in 2018 - US\$ 1,593/kW⁸, with the rest of the world, it is slightly above the global weighted average installed cost of US\$ 1,497/kW⁹ (IRENA, 2019), but is below the average of some countries, such as the United States (US\$ 1,660/kW), Germany (US\$ 1,830/kW), France (US\$ 1,870/kW) and the United Kingdom (US\$ 2,030/kW).

As Figure 22 shows, although the maximum and minimum values of the investment costs identified are similar, especially in the last three years, the median (and quartiles) has shown a downward trend. In 2017, the median of the observed

⁸ Average Dollar for the year 2018: R\$ 3,6542. Source: <http://www.ipeadata.gov.br/ExibeSerie.aspx?serid=31924&module=M&chart=ChartsImage40417902344583176>

⁹ IRENA (2019), Renewable Power Generation Costs in 2018, International Renewable Energy Agency, Abu Dhabi

sample was around R\$ 6,000/kW and, with the reduction of the values in the following years, this parameter goes to a level lower than R\$ 5,000/kW in 2019.

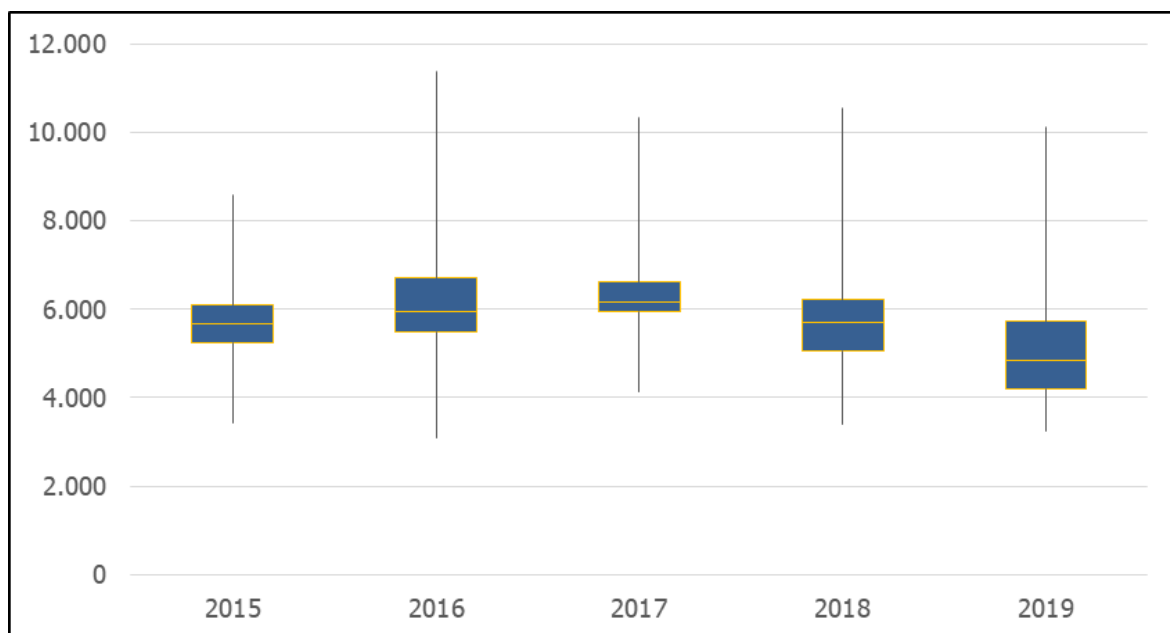


Figure 22 - Maximum, minimum and quartile values of the investment costs of the licensed projects, in R\$/kW.

As a result of the maturity of the source, the projected investment costs have been reducing significantly over the years and this process reflect can be seen on the results of the recent energy auctions, which will be discussed in the next topic.

3.7 Energy Purchase and Prices

In auctions between 2009 and 2019, around 8,000 MW_{mean} of wind energy were contracted (Figure 23) from projects in 7 states of the northeast and in one state of the southern regions of Brazil. More than 50% of this energy comes from projects in Bahia and Rio Grande do Norte states. Piauí is the third state in terms of wind energy purchased in the auctions, followed by Ceará and Rio Grande do Sul states. These three states have roughly 30% of the contracted energy. In 2016 there was no purchase.

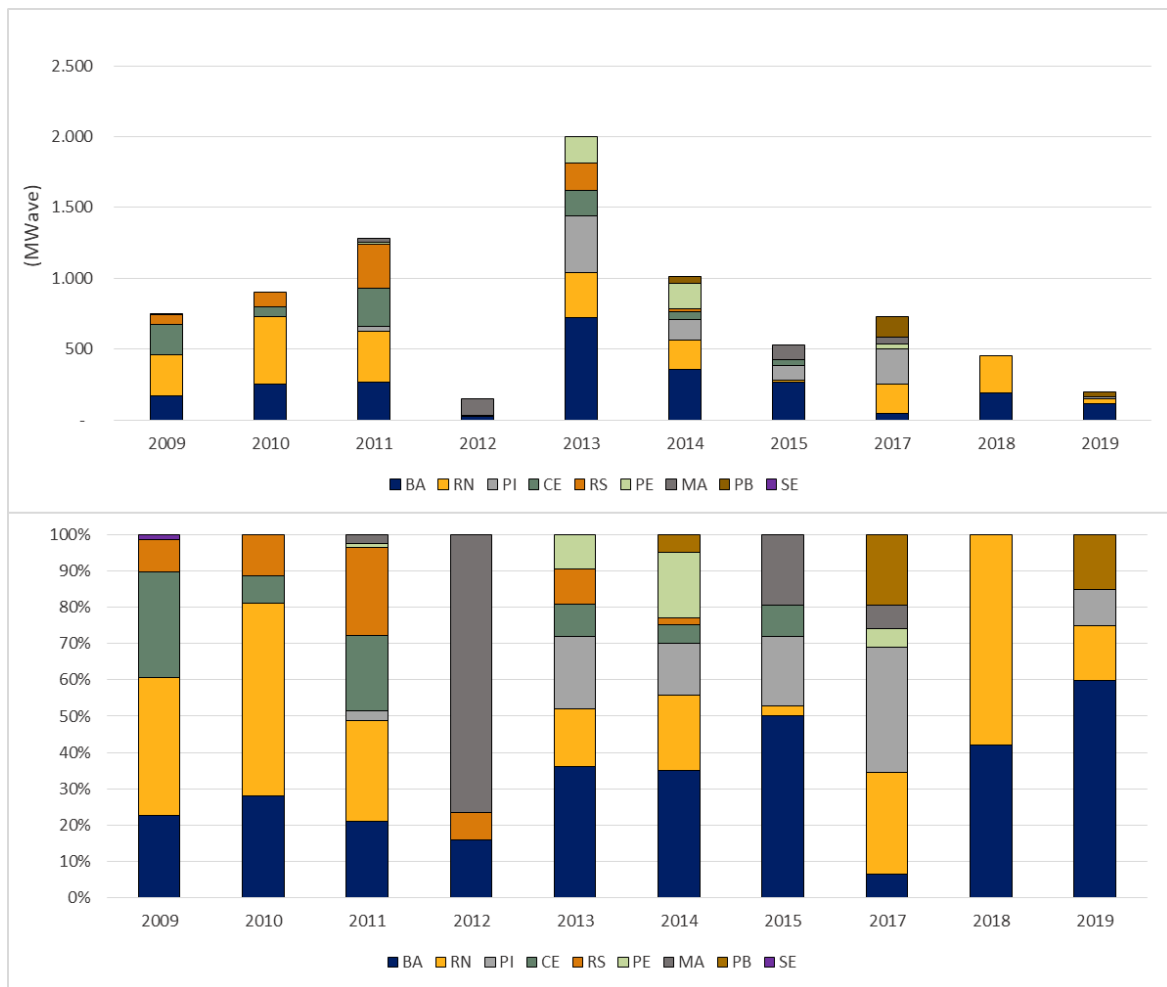


Figure 23- Absolute and relative evolution of wind energy purchase by state
Source: Adapted from CCEE (2019).

Figure 24 shows the contracted energy by year of the expected start-up date, highlighting the 2018 starting projects, contracted in A-5/2013 auction and in both 2015 auctions. On the one hand, the graph reveals the industry challenges in maintaining variable production levels over the years. On the other hand, it is necessary to consider that some parks anticipate the start of operations, while others delay and there are also new projects in the Free Market (ACL in Portuguese).

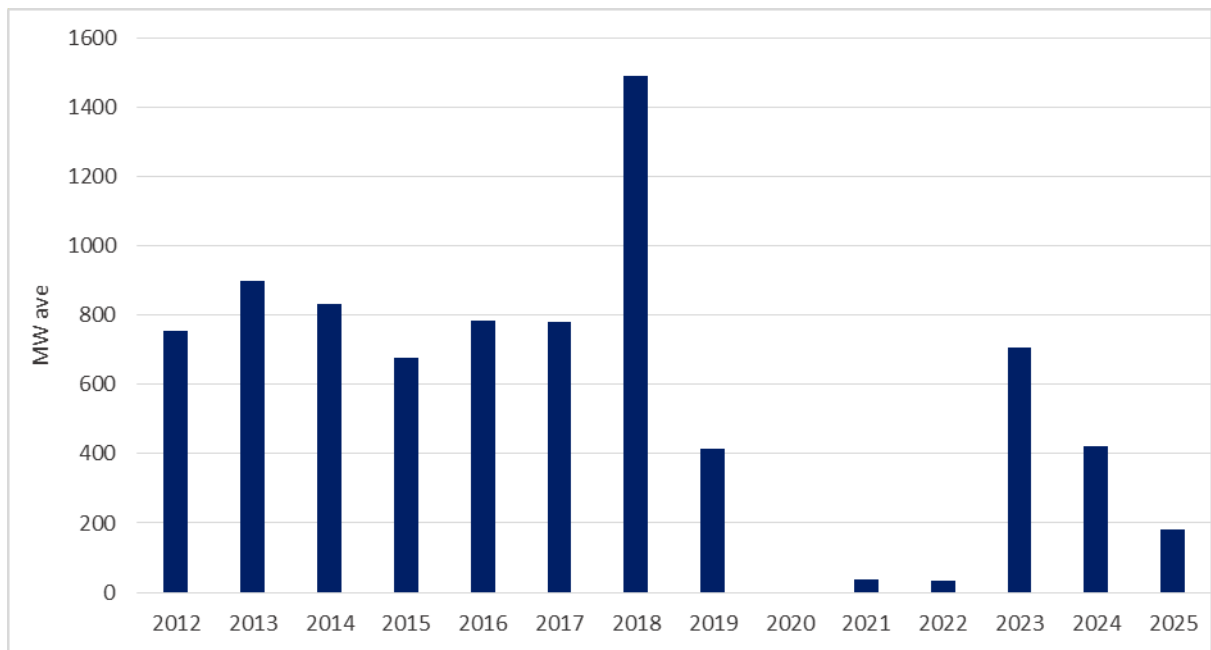


Figure 24- Wind energy contracted in auctions by year of commercial start-up.

Source: Adapted from CCEE (2019)

In the energy auctions in which wind source participated in the last three years, there was a great competition in the bids and power purchase contracts were negotiated below R\$ 100/MWh. It represents discounts between 50% and 60% in relation to the cap prices as indicated in Figure 25. The values shown were updated to the same reference date (Oct/2019) considering the Brazilian inflation index (IPCA¹⁰) variation in the period.

In the graph below we can also observe the amounts of purchased energy in the last auctions. When the negotiated amount was lower, the average prices were also lower due to the greater competition associated to the large number of participants.

¹⁰ Acronym of "Broad National Consumer Price Index" (Índice Nacional de Preços ao Consumidor Amplo)

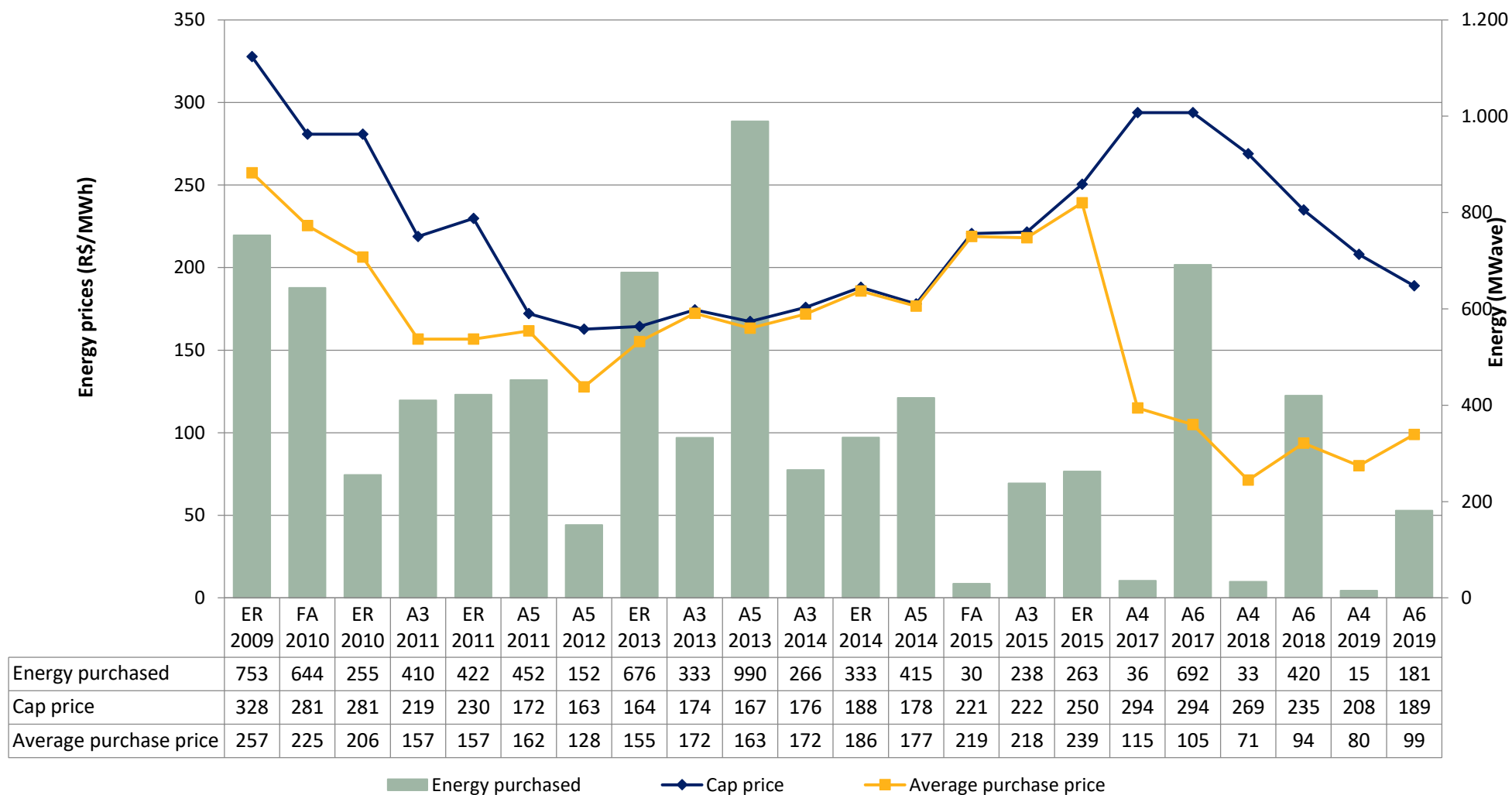


Figure 25 – Average purchase prices for wind projects in the energy auctions and the purchased energy

Source: Adapted from CCEE (2019)

Figure 26 details the results of the A-4 and A-6 auctions from 2017 to 2019, in which the price of each project is represented by a point on the graph.

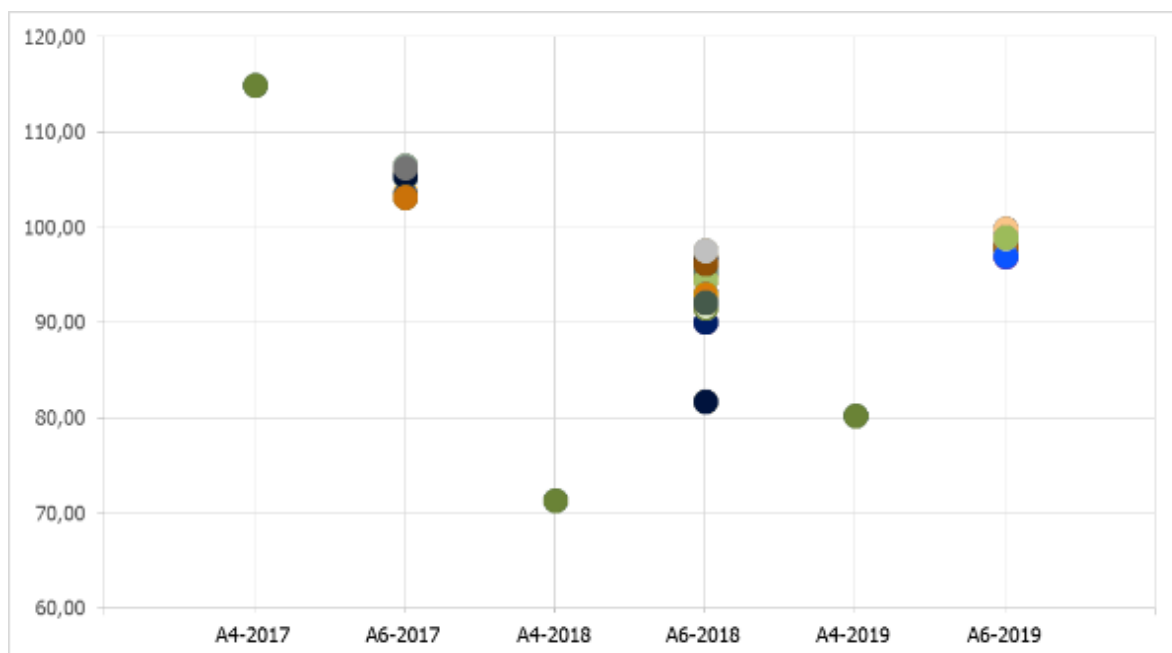


Figure 26 – Price of contracting wind farms in ACR energy auctions in R\$/MWh from 2017 to 2019 (Source: CCEE)

In auctions where prices were lower than R\$100/MWh (e.g.:A-4/2018), around US\$25/MWh¹¹, most wind projects sold less than its total firm energy certificate (around 30%). It shows that a part of the firm energy certificate is going to free market PPAs, which is a relevant strategy for price reduction in the bids. Such a strategy has been usual in recent auctions even for other sources and it reveals the increasing importance of the Free Market.

¹¹ Exchange rate (average 2019) = R\$ 3,9445/US\$. Source: <http://www.ipeadata.gov.br>

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