Brazil country report

International experiences in designing and implementing renewable energy auctions for sub-Saharan Africa

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Acronyms and abbreviations

ACL	*Ambiente de Contratação Livre* (non-regulated market of energy)
ACR	*Ambiente de Contratação Regulada* (regulated market of energy – captive consumers supplied by the distributions companies)
ANEEL	*Agência Nacional de Energia Elétrica* (Brazilian National Electricity Agency)
BNDES	*Banco Nacional de Desenvolvimento Econômico e Social* (Brazilian Development Bank)
CONAMA	*Conselho Nacional do Meio Ambiente* (body to establish the directives of the permitting process)
CAPEX	Capital expenditure
CCEE	*Câmara de Comercialização de Energia Elétrica* (new Brazilian market operator that replaced MAE)
CMSE	*Comitê de Monitoramento do Setor Elétrico* (Electricity Sector Monitoring Committee)
CNPE	*Conselho Nacional de Política Energética* (National Council for Energy Policy)
EPE	*Empresa de Pesquisa Energética* (Energy Research Office – the federal body responsible for energy planning and the prequalification of registered projects)
GDP	Gross domestic product
IBAMA	*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* (Brazilian National Environmental Agency)
IPP	Independent power producer
MAE	*Mercado Atacadista de Energia* (Brazilian first market authority that was replaced by CCEE)
MCO	Marginal cost of operation
MMA	*Ministério do Meio Ambiente* (Ministry of Environment)
MME	Ministry of Mines and Energy
ONS	Brazilian Independent System Operator
PDE	Plano Decenal de Expansão de Energia (ten-year energy expansion plan)
PPA	Power purchase agreement
PROEOLICA	*Programa Emergencial de Energia Eólico* (wind power plant programme)
PROINFA	*Programa de Incentivos às Fontes Alternativas de Energia Elétrica* (alternative energy programme)
PV	Photovoltaic
RES	Renewable energy sources
SELIC	*Sistema Especial de Liquidação e de Custódia* (Special System for Settlement and Custody)
SPV	Specific purpose vehicle
WACC	Weighted average cost of capital
WPE	Wind Power Energia

1. Introduction

The development of renewable energy sources (RES) in Brazil was the outcome of the public policies and regulatory reforms implemented during the 1990s and 2000s. The Brazilian government launched the first institutional reform in 1995 to restore investment capacity and attract private capital to the power sector, after severe hyperinflation and fiscal crises in the 1980s.

The institutional model designed in 1995, however, was not able to guarantee security of supply, and Brazilian consumers had to endure rationing of energy in 2001. Consequently, on 15 March 2004, the federal government approved Act 10.848, which started the second institutional reform of the Brazilian energy system, with four explicit aims (Tolmasquim, 2014): guarantee security of energy supply and resource adequacy in investment; ensure fair and cost-reflective tariffs; reintroduce central planning to cope with demand growth (indicative for generation expansion and determinative for transmission expansion); and build a stable regulatory framework.

Regarding security of supply and the fairness of tariffs, the second reform promoted the use of energy auctions as the primary mechanism to procure energy and capacity with a long-term focus.

The first auction concluded under the framework of the second institutional reform, realised on 12 December 2004, procured energy from existing power plants. The auction acquired 1 192.7 TWh at an average price of US$23.12/MWh. The total amount transacted, considering the 8-year duration of the contracts, surpassed US$27.5 billion.

The first procurement for greenfields projects was performed on 16 December 2005, with 30-year contracts for hydropower plants and 15-year contracts for thermal power plants, including biomass. For this first auction the lead time was three, four and five years for both technologies. The outcome was the acquisition of 564 TWh at the average price of US$53.16/MWh. The total amount transacted, considering the duration of the contracts, surpassed US$29.9 billion.

These two first auctions laid the foundation for implementing methodology and designing the Brazilian auction programme.

Between December 2004 and October 2019, the Brazilian programme performed 82 rounds and contracted 9.571 TWh of energy (Table 6). Regarding only new power plants, the amount of contracted energy was 8.180 TWh, adding 105.2 GW, 76.8 GW of which were from RE (see Figures 17 and 18). The success of the Brazilian auction programme depended to a large extent on the attention given by the public authorities to the design of the auctions, including the regulatory framework and the implementation process. In fact, since 2004, the auctions have been performed following the same rules and structure, with only minor adjustments in contractual clauses and in the bidding mechanism to mitigate the risk of connection delays.

Brazil's experience highlights the importance of considering three main goals when designing auctions. First, auctions must be attractive enough to investors to generate competition and to achieve optimal prices. Second, the auction design must ensure the commitment and reliability of the bidders and their technical and financial capability to build projects on schedule and deliver the promised energy. Third, the auction design should ensure the acquisition of the right mix of energy sources to safeguard the security of the electric system (Viscidi & Yépez, 2020).

To improve the attractiveness of the auctions, the public authorities provided comprehensive information about the auction programme, schedule and technologies through a 10-year power system expansion plan, including generation and transmission.

The bidding stage of the auction is preceded by a qualifying phase to ensure the commitment and reliability of the bidders. Developers must provide the land use rights and the preliminary environmental permit necessary to develop their projects and demonstrate technical and financial capability to build projects on schedule and deliver the promised energy. Bidders must also provide a bid bond before joining the bidding stage of the auction, and winners must provide surety and performance bonds before contract signing.

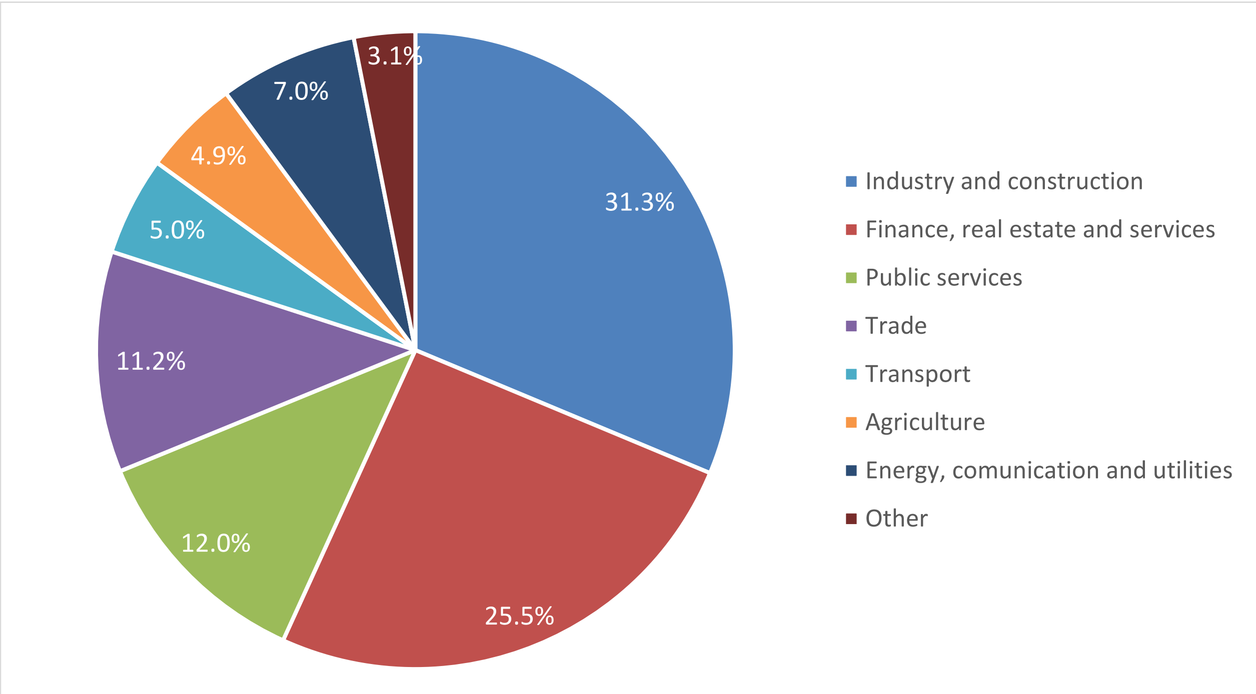
To ensure energy security and the optimal mix of sources, the Brazilian auctions procure energy using both technology-neutral and technology-specific auctions. Reserve capacity is also procured by public auctions, using the same scheme and methodology developed for energy procurement.

The following sections provide an introduction to Brazil and its power sector; a description and analysis of the Brazilian auction design, including auction volumes, qualification criteria and processes, bidder ranking and winner selection, buyer and seller liabilities and approaches to project derisking and credit enhancement; a reflection on the key lessons learned with the Brazilian experience; and some conclusions.

2. Brazil overview

Brazil is South America's largest country, and the fifth largest in the world, covering over 8 million km². With a Gross Domestic Product (GDP) of US$2.020 billion in 2019 (Table 1 and Figure 1), and 210.15 million inhabitants, Brazil was the ninth largest economy in the world before the COVID-19 pandemic. However, the Brazilian economy had been struggling with a lack of dynamism since 2014: GDP grew by 0.5 per cent in 2014; contracted by 3.55 per cent and 3.28 per cent respectively in 2015 and 2016; grew by 1.32 per cent in 2017 and 2018, and by 1.14 per cent in 2019. The unemployment rate rose from 6.4 per cent in January 2014 to 13.7 per cent in March 2017.

Figure 1: Contributors to the Brazilian GPD, December 2019



Source: Brazilian Central Bank (www.bcb.gov.br, accessed June 2020)

Interest rates (Special System for Settlement and Custody/*Sistema Especial de Liquidação e de Custódia*, or SELIC[1]) and inflation have been on a downward trajectory since 2016. In April 2020, the annual consumer price index was 2.4 per cent, below the target of 2.5–5.5 per cent and considerably lower than the 10.67 per cent recorded in December 2015 (Table 1). The SELIC dropped from 14.25 per cent in December 2015 to 3 per cent in May 2020.

[1] The central bank/interbank lending rate.

Table 1: Brazilian key economic indicators

	December 2015	December 2019	April 2020
Population	**203.48 million**	**210.15 million**	-
GDP	**US$1.802 billion**	**US$2.020 billion**	-
GDP annual variation	**-3.55%**	**1.14%**	-
GDP per capita	US$8.856	US$9.612	-
Unemployment rate (%)	8.9	11	12.6
Consumer price index (%)	10.67	4.31	2.4
Basic interest rate (%)	14.25	4.5	3.75
Corporate tax rate (%)	34	34	34
Sale tax rate (%)	17	17	17
Social security rate for companies (%)	28	28	28
Social security rate for employees (%)	11	11	11

Source: Brazilian Central Bank (www.bcb.gov.br, accessed June 2020)

2.1. Brazilian power sector

2.1.1. Introduction

The Brazilian power sector was initially dominated by state-owned companies. The distribution service was provided by monopolist companies owned by local state or municipal governments. Generation and transmission were mainly supplied by the subsidiaries of the federal company Eletrobras,[2] and by companies owned by the state-level governments of São Paulo, Minas Gerais, Goiás and Paraná (*Companhia Energética de São Paulo*, or Cesp; *Companhia Energética de Minas Gerais*, or Cemig; *Companhia Energética de Goiás*, or Celg; and *Companhia Paranaense de Energia*, or Copel, respectively). Eletrobras was responsible for planning the expansion of transmission and power generation and the dispatch of power plants. The federal government retained the exclusive authority to enact electricity sector legislation and was responsible for calculating end-user tariffs.

The state-led model worked well until the second oil shock in 1979 and the deepening of the Brazilian fiscal and hyperinflation crisis during the 1980s. In fact, between 1970 and 1995, installed capacity had grown by 435 per cent. Still, the power companies lost their financial health and investment capability due to the tariff control imposed by the federal government to reduce the impact of inflation.

To restore the investment capacity and attract private capital to the power sector, the Brazilian government launched the first institutional reform in 1995, with the following goals (World Bank Group: Energy and Extractives, 2012):

- Electricity generation, transmission, distribution, and trading/marketing should be unbundled into separate segments;
- Electricity generation should become a competitive activity at the risk of the Independent Power Producers (IPP), with prices set by the market;
- Large consumers should be allowed to buy energy freely in the market;
- The transmission utilities should remain as a natural monopoly, with regulation ensuring open access to generators, distribution companies, free consumers and other transmission utilities;

[2] Furnas, Chesf, Eletronorte, Eletrosul, Eletronuclear and Itaipu.

- The distribution companies should also be treated as a natural monopoly and should remain responsible for providing distribution services with open access to free consumers and for buying energy from IPPs to supply their regulated customers;
- An independent regulator would serve as a watchdog for the market, interpreter of specific legislation and guarantor of the stability of rules;
- Boosting supply as an investment opportunity must be left to the market agents.

The institutional reform was only completed in 1997 when Congress approved the legal framework[3] that creates the National Electricity Agency (*Agência Nacional de Energia Elétrica*, or ANEEL), the Independent System Operator (ONS) and the Wholesale Energy Market Authority (*Mercado Atacadista de Energia*, or MAE).

According to the initial model, large consumers could sign power purchase agreements (PPA) directly with the IPPs or energy traders. In contrast, the other consumers remained supplied by the local distribution company under a regulated tariff defined by ANEEL.

The signed contracts, both by free consumers and distribution companies, had to be registered with the MAE. Any deficit between what was contracted through PPAs and what was consumed needed to be bought by free consumers and distribution companies on the spot market at the marginal cost of operation (MCO) calculated by the ONS.

The ONS was also responsible for the dispatch of power plants (considering the MCO in a tight pool[4] approach), planning for the expansion of the transmission grid and granting grid access to consumers and producers.

The Brazilian Ministry of Mines and Energy (MME) remained responsible for providing general guidance on sector regulation and granting concession contracts to large hydropower plants, transmission lines and privatised distribution companies.

New transmission utilities were auctioned as public–private partnership concessions based on a Build, Operation and Transfer model, and every new concession of a transmission utility was established as a specific purpose vehicle (SPV).

The institutional model designed in 1995 was not able to guarantee security of supply. In April 2001, the central hydropower plants' reservoir levels had dropped to around 32 per cent of their maximum capacities, with energy deficit risks topping 15 per cent, 10 percentage points higher than the acceptable threshold of 5 per cent.

On 1 June 2001, the government was forced to decree electricity rationing in Southeast, Centre-West, North and Northeast Brazil. The government established consumption quotas as the main rationing mechanism. In parallel, government also surcharged consumers for excess consumption, introduced bonuses for residential consumers whose energy use fell below their targets, and scheduled power cuts for residential consumers exceeding their quotas. The rationing resulted in total electricity consumption shrinking by 25 per cent. Residential consumption fell by 13 per cent and remained at this level during the following years, while

[3] Acts 9.074, 9.427 and 9.648.

[4] In the tight pool model, the dispatch is centralised and based on predetermined variable costs. For comparison, in the loose pool model, the dispatch is centralised, but the generators are free to offer any price they like; such an approach is also referred to as price-based pools. Finally, the dispatch can be decentralised and entirely based on price.

self-production increased from 7.5 per cent to 10.5 per cent of consumption in six months (Hermes de Araújo et al., 2008).

In the same year, the government set up a commission to identify the structural and contextual causes of the imbalance between energy supply and demand. As the commission noted, the power sector institutions could have addressed the vulnerability of the Brazilian power system earlier, as this system had been teetering on the verge of collapse since 1999. Adverse hydrology merely precipitated the energy crisis, which was entirely foreseeable under the circumstances in place at that time. The main factor behind Brazil's electricity crisis was the delay in the start-up of operations of power generation and transmission projects, together with the absence of new generation companies.

Indeed, the main reasons for the rationing were that the installed capacity did not follow the energy demand growth. The economic signal provided by the spot market in a hydro system with big reservoirs was too risky for investors who depend only on the spot market revenue. Most of Brazil's electricity is supplied by large hydroelectric plants. Unlike coal, oil or gas plants, their cost of operation is practically zero. Thermal plants play an essential role in complementing the water system, but not in competing with it. While the market would happily accept and pay a reasonable price for the production of new natural gas plants in the dry season, a 'wet' year would see little demand for gas generation, and the price paid for electricity would remain at a low level.

In short, building gas plants would be like making a climate-based bet for the next decade. Three rainy years in a row and the project would be bankrupt. Considering this, the lack of investment in Brazil is not a mystery. State-owned companies had their investments restricted due to a federal budget deficit and private companies considered the risks too high and the profits too low.

The experience built up by Brazil during its rationing crisis in 2001 underscored the need to modify the market design of the Brazilian power sector. The absence of long-term PPAs was too risky for private capital.

Consequently, on 15 March 2004, the federal government approved Act 10.848, which started the second institutional reform of the Brazilian energy system, with four explicit aims (Tolmasquim, 2014): guarantee security of energy supply and resource adequacy in investment; ensure fair and cost-reflective tariffs; reintroduce central planning to cope with demand growth; and build a stable regulatory framework.

Regarding security of supply and the fairness of tariffs, the second reform of the Brazilian energy system promoted (Correia et al., 2006):

- The segregation of the regulated market (*Ambiente de Contratação Regulada*, or ACR) into one where distribution companies procure energy contracts to supply the captive consumers, and a free market (*Ambiente de Contratação Livre*, or ACL) where IPPs, energy traders and free consumers can transact energy;
- The use of an auction scheme to procure energy for the ACR;
- The use of long-term contracts in the ACR to reduce price volatility and enable the use of accounts receivable arrangements as collateral for project financing (seeFigure 15;
- The obligation of contractual coverage by distributors and free consumers, leaving the spot market only for imbalances;

- The obligation to back all contracts with firm energy (physical coverage[5]) certified by the Brazilian MME to each power plant. In practice, the contracts must indicate the power plants that will produce the energy and be limited to the firm energy certified by the MME for each power plant. This avoids the situation in which a plant sells more energy through bilateral contracts than it can produce given a certain risk level established by governmental regulation.

The second reform also restored central planning and the role of the MME in the oversight of the sector, with the creation, in 2004, of the Electrical Sector Monitoring Committee, and of the Energy Research Office (*Empresa de Pesquisa Energética*, or EPE) to support MME with energy planning. The ONS retained the responsibility for short-term planning in transmission.

Finally, to improve the regulatory framework, the reform replaced the MAE with a new market operator (*Câmara de Comercialização de Energia Elétrica*, or CCEE) with more robust and more transparent governance and under the direct oversight of ANEEL (Table 2).

Table 2: Key institutions in the Brazilian electricity sector

National Council for Energy Policy (CNPE)	The CNPE is the council of ministries (Mines and Energy, Foreign Affairs, Economy, Infrastructure, Agriculture, Science and Technology, Environment, Regional Development, Security Office and president of the EPE) and representatives of states, civil society and university that advise the president of the Republic in the formulation of energy policies.
Electricity Sector Monitoring Committee (CMSE)	The CMSE is formed by representatives of the MME, ANEEL, ONS and CCEE and is responsible for monitoring energy security.
Brazilian Ministry of Mines and Energy (MME)	The MME is responsible for designing policies and ensuring the adequacy of energy supply, setting goals for universal electricity access and greenhouse gas emissions, and long and medium-term central planning.
Brazilian National Electricity Agency (ANEEL)	ANEEL is responsible for regulating the entire value chain of the electricity sector, including tariff and rate setting for distribution and transmission services and the approval of the ONS annual budget. ANEEL is also responsible for generation and transmission auctioning. The board of ANEEL is composed of 5 directors, all appointed by the Brazilian president and confirmed by the Senate.
Brazilian Independent System Operator (ONS)	The ONS is responsible for granting grid access for producers and users, for short-term planning, for determining reinforcements and improvements in transmission assets, subject to ANEEL's approval, and for dispatching power plants according to the merit of cost and transmission constraints. Five directors compose the board of the ONS, 3 indicated by the MME and 2 elected by the IPPs and transmission agents.
Brazilian Market Authority (CCEE)	The CCEE is responsible for measuring the generation and consumption of each agent in the market, including the losses in the grid, for identifying contractual imbalances, and for clearing the market at the spot price. The CCEE is also responsible for the management of sectorial charges and funds used for fostering renewable sources and for subsidising low-income and rural customers supplied by distribution companies in the regulated market. The board of the CCEE is composed of 5 directors, the chairman indicated by the MME and 4 elected by the IPPs, the distribution companies, the free consumers and the energy traders.

[5] In Portuguese, *garantia física*. It refers to the expected generation of energy that the power plant will be able to provide under critical conditions, especially regarding the seasonality and variability of RE sources.

Brazilian Energy Research Office (EPE)	The primary role of the EPE is to support the MME with studies and research on long and medium-term energy and transmission planning. The ONS retains responsibility for short-term transmission planning.
Brazilian National Environmental Agency (IBAMA)	IBAMA is responsible for the social and environmental licensing of generation and transmission projects with national impact. State-level agencies license projects with local impact.
Independent Power Producers (IPPs)	As a general rule, the IPPs are subject only to technical regulation regarding standards for operation and dispatch and the social and environmental conditions for licensing. Large hydropower plants, however, need a concession grant to exploit the generation potential of the rivers.
Transmission SPVs	The transmission SPVs are responsible for building, operating and, at the end of the concession contract, transferring the transmission assets auctioned by ANEEL, as well as providing the investment in the reinforcements and improvements requested by the ONS and approved by ANEEL.
Distribution companies	The distribution companies are responsible for building, operating and, at the end of the concession contract, transferring distribution assets in their service area, and for contracting energy through the auctions of the ACR to supply their regulated customers.
Energy traders	The energy traders are agents that buy energy from IPPs to resell to free consumers.
Free consumers	The free consumers are large users of electricity that choose to procure their energy in the ACL, contracting with energy traders or IPPs. Once the choice for the ACL is made, free consumers must remain in the open market for at least 5 years.

Source: Authors' compilation

2.1.2. Power sector structure

The second sectorial reform was successful in creating a buoyant market with an increasing number of agents, especially IPPs, energy traders and free consumers (Table 3).

Table 3: Number of agents in the Brazilian electricity market, various years

Year	2000	2005	2010	2019
Independent power producers	17	87	290	1 488
Energy traders	5	47	93	341
Free consumers	0	470	940	7 057
Self-producers	0	14	34	76

Source: CCEE (www.ccee.org.br, accessed June 2020)

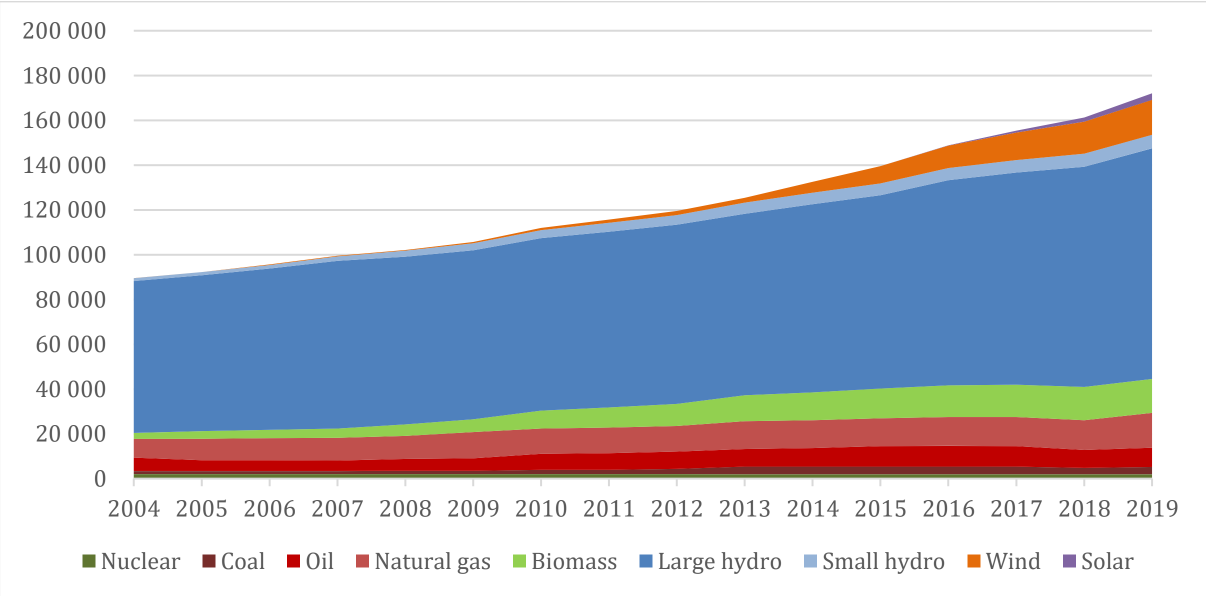
The energy supply mix had also evolved, from a system strongly dependent on sizeable hydropower plants with a relatively small nuclear and fossil complement, to a system with deep penetration of wind, biomass and solar (Table 4 and Figure 2).

Table 4: The Brazilian electricity sector, December 2019

	GW	%
Total capacity	174.02	**100**
Large hydro	102.99	59.2
Wind	15.59	**9.0**
Gas	15.56	**8.9**
Biomass and waste	15.15	**8.7**
Oil	8.59	**4.9**
Small hydro	6.10	**3.5**
Coal	3.20	**1.8**
Solar photovoltaic (PV)	2.89	**1.7**
Nuclear	1.99	**1.2**
Others	1.96	1.1
Urban electricity access rates		**99.96%**
Rural electricity access rates		**98.20%***
Peak demand	**85.97**	**GWh/h**

Note: * This value includes both on-grid and off-grid supply solutions.
Source: ANEEL (www.aneel.gov.br, accessed June 2020) and EPE (www.epe.gov.br, accessed June 2020)

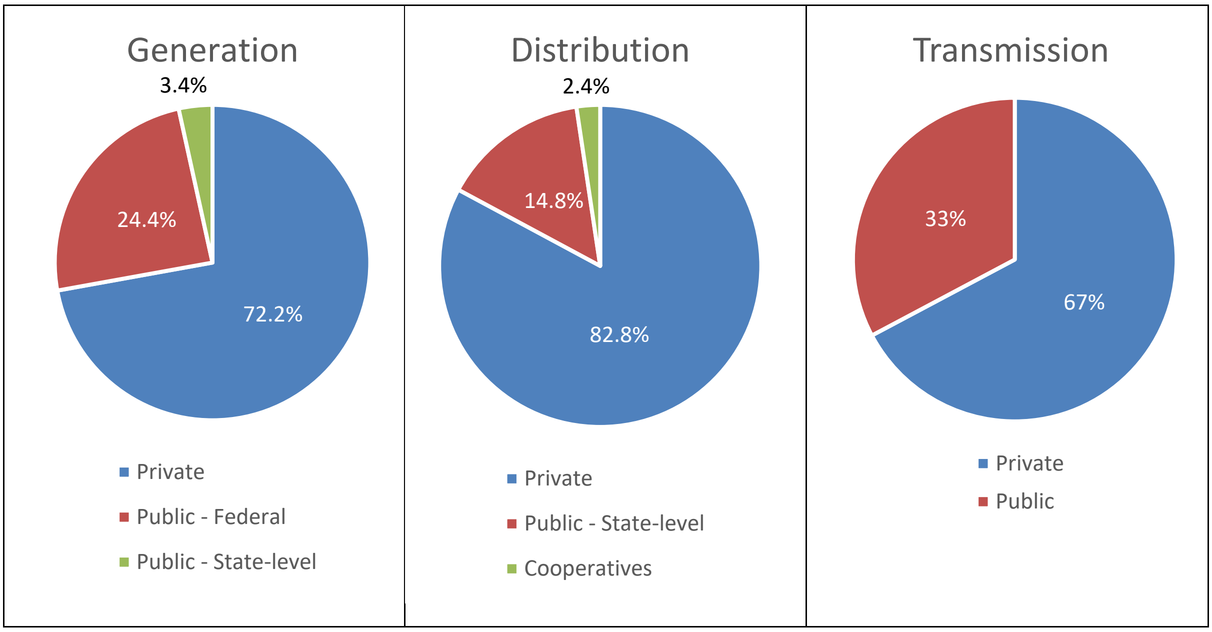
Figure 2: Installed electricity generation capacity (MW), 2004–2019



Source: EPE (www.epe.gov.br, accessed June 2020)

The capital structure remained mixed, with state-owned and private companies competing in all activities and the private sector focused on new capacity investment rather than on the privatisation of state-owned companies (Figure 3).

Figure 3: Brazilian capital structure, 2019



Source: ANEEL (www.aneel.gov.br, accessed June 2020)

2.1.3. Tariff setting and financial sustainability

During the 1980s, in an effort to control hyperinflation, distribution tariffs were kept at artificially low levels. Still, since the state-level government owned most distribution companies, the Federal Treasury covered the deficit and financial losses of the companies. The burden of supporting inefficiently operating companies was thus borne by the Brazilian taxpayers (World Bank Group: Energy and Extractives, 2012).

In 1993 the regulation was revised to improve the financial health of the transmission and distribution companies. Under the new regulatory framework, the transmission and distribution tariffs were defined in the concession contracts and became cost-reflective.

The transmission tariff is set by the winning bid in the transmission auction, while the distribution tariff is determined by the Brazilian Regulatory Agency considering a benchmark methodology to identify efficient levels of operational expenditure and capital expenditure (CAPEX). The price of the energy is passed through to end-users, according to the winning bid in the regulated energy auction or the contractual price in the free market.

Furthermore, the contracts also stipulate periodic and extraordinary tariff review mechanisms and the tariffs are indexed to Brazilian inflation and may be reviewed in the case that the ONS and ANEEL request investment in reinforcement and improvement of the assets. ANEEL must approve the value of the investment and the weighted average cost of capital (WACC)[6] that will be applied to remunerate the transmission and distribution companies' CAPEX. The WACC rate set in 2020 is 7.32 per cent per year.

Currently, electricity distribution is performed by 53 concessionaires, including public and private companies. Electricity distribution concessionaires cannot develop any activity relating

[6] The WACC is the rate that a company is expected to pay on average to all its security holders to finance its assets. It is calculated as a weighted average cost of debt and equity. In general, WACC is used in financial modelling as the discount rate to calculate the net present value of a business/asset. Currently, the WACC applied to the distribution and transmission sectors, respectively, is 7.32 per cent per year and 6.96 per cent per year, after tax.

to power generation, transmission or energy trading. In addition, they can only acquire energy through auctions based on the lowest price and sell energy to captive power consumers under the tariff set by ANEEL.

The distribution tariff has two parts: Components A and B (Figure 4). Component A encompasses the costs of transmission, the energy contracts and sectorial charges[7] and is entirely passed through to consumers, since their costs, under the Brazilian regulation framework, are not manageable by the distribution companies. Component B embodies the distribution operation and maintenance costs, the remuneration and depreciation of investments, and the regulatory rate for losses and delinquency. ANEEL determines Component B according to a price-cap model that considers annual inflation, the expected efficiency savings (factor X) and benchmarks for efficiency for each kind of cost.

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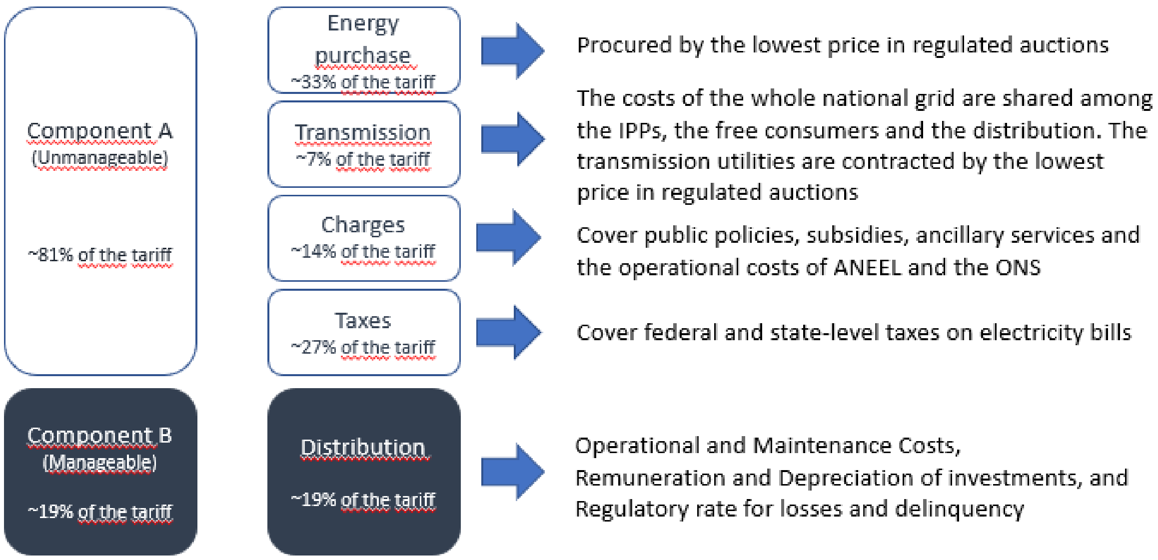
[7] The sectoral charges are meant to subsidise RE and low-income customers and to finance public policies:

- Energy Development Account (CDE): to (i) subsidise energy generated from wind, small hydropower, biomass and coal; (ii) ensure universal access to electricity; and (iii) subsidise low-income and rural customers.
- Fuel Consumption Account (CCC): covers fuel costs of thermal power generation in stand-alone systems.
- Electricity Services Inspection Fee (TFSEE): to fund the operation of ANEEL.
- Alternative Electricity Sources Incentive Program (PROINFA): a feed-in-tariff programme that contracted RE sources in 2004, before the introduction of the auctions.
- Financial Compensation for the Use of Hydro Resources (CFURH): to compensate the federal government, the states and the municipalities affected by water use and the loss of productive land caused by flooding areas required to form the reservoirs needed by hydropower plants.
- Research and development (R&D) and energy efficiency: encourage scientific and technological research related to the power sector. Concessionaires and permit holders engaged in public electricity distribution services must allocate a percentage of their net operating revenues each year to R&D of power sector and energy efficiency programmes for both supply and demand.
- Energy Reserve Charge (EER): cover the costs of contracting reserve energy.
- System Services Charge (ESS): cover the costs incurred due to: (i) operating constraints; (ii) rendering ancillary services; and (iii) energy security.

In addition to the sectorial charges, the distributor also pays to cover the costs of the ONS and CCEE.

Figure 4: Brazilian distribution tariff setting mechanism



Source: ANEEL (www.aneel.gov.br, accessed June 2020)

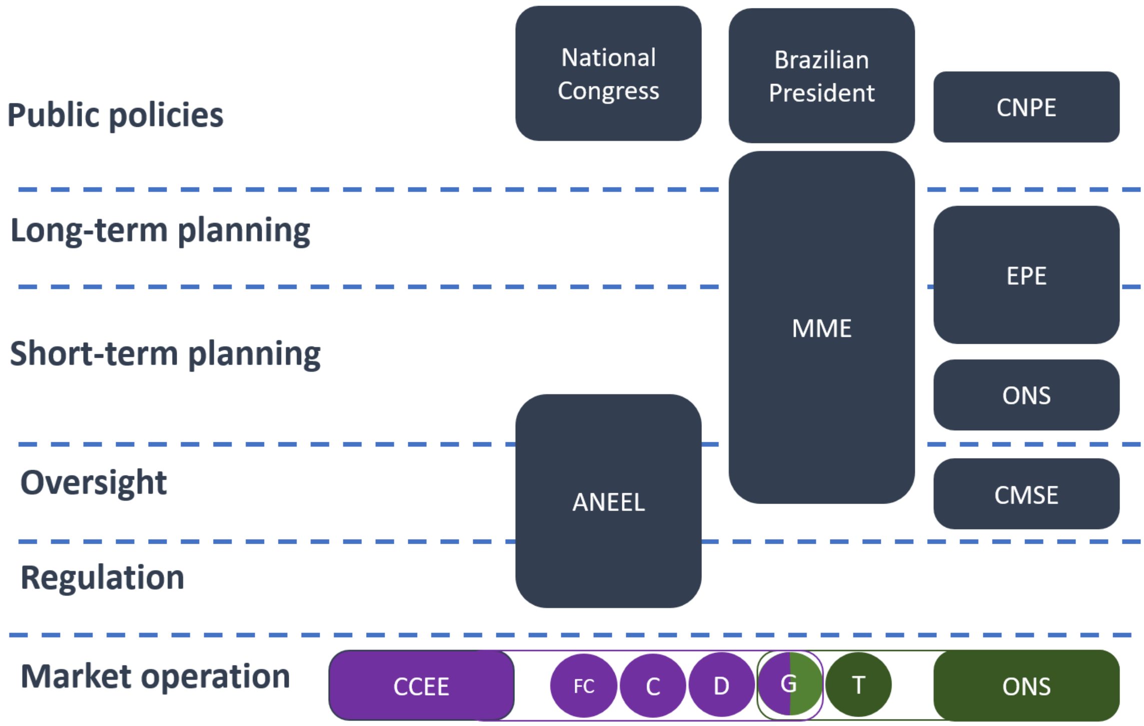
This approach ensured the financial health of the sector agents, especially the distribution companies that, in the Brazilian model, are the main off-takers of energy. According to the ANEEL oversight, in March 2019, 39 distribution companies (74 per cent) had good and acceptable levels of economic and financial sustainability and 14 had negative EBITDA (earnings before interest, taxes, depreciation and amortisation).

2.1.4. Regulatory and policy framework

2.1.4.1. Regulatory framework

The power sector regulatory framework is given by a set of laws, decrees and resolutions issued by the National Congress, Presidency, MME and ANEEL. Over the past few years, the Brazilian electricity sector has undergone structural changes in its regulation. The objective has been the establishment of a model that would promote economic efficiency through the competitive environment, especially in the generation sector, which would make investments in the expansion of installed capacity feasible and guarantee service to the consumer market. Figure 5 illustrates the organisations and institutions of the Brazilian power sector.

Figure 5: Brazilian regulatory framework



Source: Authors' compilation

EPE deserves special mention as one of the most important institutional innovations of the new regulatory framework. Brazil's government determined that it was necessary to have an institution based on knowledge and technical excellence, with permanent high-level professional staff, tools and a database suitable for the formulation of energy policies and decision support. EPE is a federal body, created by Act 10.847 on March 2004, mainly responsible for energy planning. EPE develops 10-year plans (*Plano Decenal de Expansão de Energia*, or PDE), periodic bulletins, reviews, reports and specific studies based on government guidelines. The PDE indicates government's expectation about energy expansion according to an integrated view for all relevant energy sources and synergies with other economic sectors. The PDE also prioritises transmission facilities to be considered by MME to participate in transmission auctions. The EPE also provides a range of analyses and reports on energy statistics, energy efficiency and socio-environmental studies (including environmental feasibility and sustainability of electricity and gas production and transmission sources, energy resource inventory and prospection for the preliminary environment licensing process of strategic hydropower and transmissions projects).

2.1.4.2. Policy framework

The first incentive for RE dates back to 1996 and is still in force. Act 9.427 established a 50 per cent discount in transmission and distribution system tariffs for RE. All other energy sources and consumers offset this cross-subsidy.

The first attempt to implement public policies with explicit targets for RE was the wind power plant programme (*Programa Emergencial de Energia Eólico*, or PROEOLICA). It was designed in 2001 to hire 1 050 MW of wind power plants until December 2003 using a feed-in-tariff approach. The PROEOLICA was, however, never implemented.

In 2002 Congress approved the alternative energy programme PROINFA (*Programa de Incentivos às Fontes Alternativas de Energia Elétrica*) – also a feed-in tariff policy, aimed to acquire, in its first phase, 3 300 MW of RE (1 100 MW each from wind, biomass and small hydropower plants) under 20-year PPAs. The first phase was implemented in May 2004 and a total of 6 600 MW responded to the government call for projects (3 681 MW from wind, 995 MW from biomass and 1 924 MW from small hydropower plants). The projects were selected according to the age of their environmental licences and the unmet power of biomass was redistributed among the other sources (Costa, 2006). Table 5 illustrates the outcome of PROINFA's first phase.

Table 5: PROINFA's first-phase outcome

Source	Capacity	Price
Wind	1 422.92 MW	US$65.94/MWh
Small hydro	1 191.24 MW	US$37.76/MWh
Biomass	685.24 MW	US$30.25/MWh
Total	3 299.40 MW	

Source: Costa (2006)

PROINFA also provided for a second phase where alternative RES should serve 15 per cent of the annual increase in electricity consumption. Over a 20-year horizon, these sources would represent 10 per cent of the total electricity consumption. However, because of the power sector reform, the government decided not to implement the second phase. Instead, it decided to replace the feed-in tariff policy with regulated auctions (presented in detail in the next section).

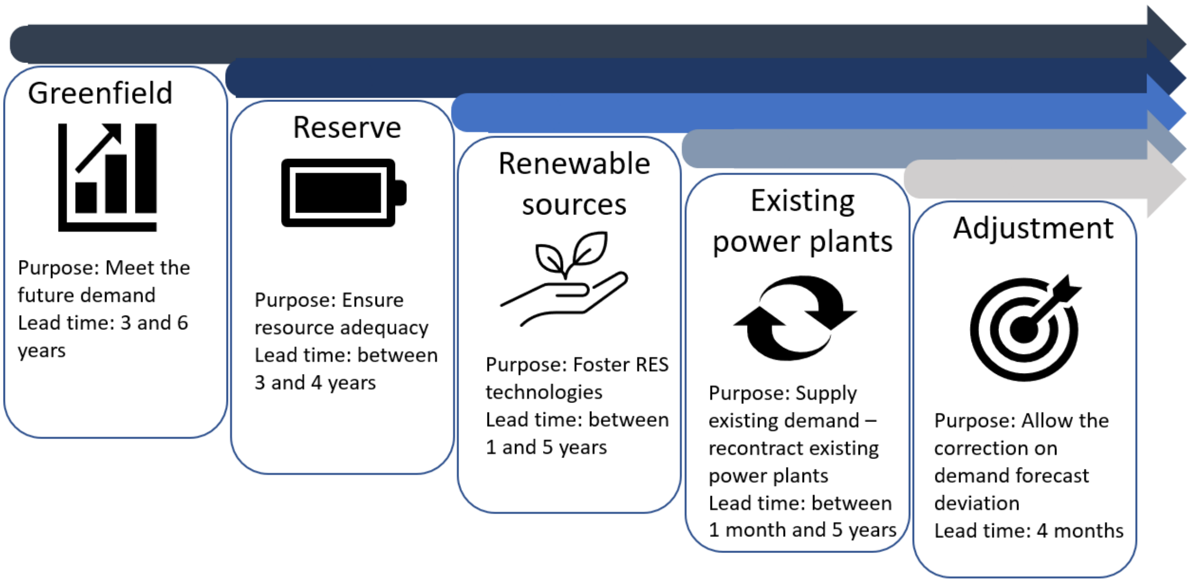
In 2016 the Brazilian government committed to increasing the share of non-hydro renewable sources in its power supply mix from 9 per cent in 2014 to 24 per cent in 2030. To that point, the government had not disclosed any Nationally Determined Contribution implementation plan for energy. However, the continuity of the auctions will allow the country to achieve the chosen target quickly. As shown in Table 4 and Figure 2, the installed capacity of wind, solar PV and biomass is already around 19 per cent, and the 10-year energy expansion plan indicates that including distributed PV, they will achieve 34 per cent in 2029.

3. Renewable energy auctions

The Brazilian auction programme was created by Act 10.848 with the objective to provide an efficient, transparent and competitive instrument for the awarding of long-term PPAs for captive consumers supplied by the distribution companies. Since 2005 all the energy contracts[8] in the ACR have been secured through an auction scheme prioritising the procurement of greenfield projects to meet demand growth.[9] The auctions have been designed to provide long-term contracts to new power plants and facilitate their financing through project finance, where lenders provide loans based on the projected cash flows of the project rather than on the balance sheets of its sponsors.

There are five types of energy auctions: greenfield auction, reserve auction, renewable source auction, existing power plant auction and adjustment auction (Figure 6).

Figure 6: Brazilian auction scheme



Source: Authors' compilation

Greenfield auction: The greenfield project auction aims to meet the increase in distributors' power demand by contracting energy from plants that have yet to be built. This auction can be of two types: A-6 (plants that go into commercial operation in up to 6 years' time) and A-4 (in 4 years). The winners of the auction sign contracts with the distribution companies that are procuring energy. Only the consumers from the regulated market pay for this energy. The

[8] The electricity commercialisation contract in the regulated market is a bilateral contract for the purchase and sale of electric energy and its associated capacity, signed between the selling company and the distribution company within the scope of the regulated market, as a result of auctions of electricity from existing generation plants and greenfield plants. In other words, there are not any separate tenders to contract energy and capacity in Brazil. That situation can be explained by the large number of hydropower plants within the power system. With the increase of run-on-river hydropower plants and variable renewable sources, capacity is becoming an issue and the government has started discussing the possibility of running capacity-only auctions.

[9] Originally, the auctions for new projects had a lead time of 5 or 3 years and lasted between 15 and 30 years.

Brazilian government has implemented 31 rounds of greenfield project auctions, with 30 rounds specifically for RE.[10]

Reserve auction: The contracting of reserve energy was originally created to increase security in the electricity supply in the National Interconnected System, with power from greenfield or existing plants specially contracted for this purpose. So far, reserve auctions have only contracted greenfield plants. CCCE act as a single buyer and sign contracts with all the winners of the auction. Reserve energy is accounted for and settled on the short-term market operated by the CCEE. This type of 'insurance' in the energy supply generated the Reserve Energy Charge intended to cover these costs – including administrative, financial and tax costs. As the reserve auction works as an insurance for all of the power system, the energy charges apply to all the consumers from the regulated and free market. The Brazilian government has implemented 9 rounds of reserve auctions, the last in 2017.

Renewable energy auction: The auction of renewable sources was instituted to meet the growth of the market in the regulated environment and increase the share of renewable sources – wind, solar, biomass and energy from small hydroelectric plants – in the Brazilian energy system. In the last years, the government has been using only greenfield auctions to procure new RE plants. The Brazilian government has implemented 3 rounds of special auctions for RES, the first in 2007 and the last in 2015.

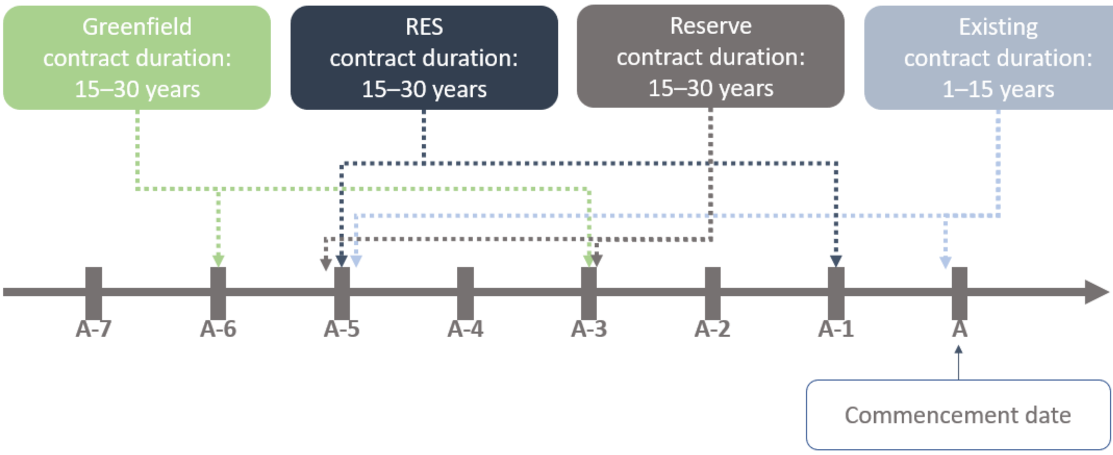
Existing power plant auction: This auction was created to contract energy generated by plants already built and in operation, whose investments have already been partially or fully amortised and, therefore, have a lower cost. The separation of the existing and greenfield energy auctions allowed the average price in the regulated market (ACR) to be calculated apart from the marginal expansion cost, thus contributing to fair electricity rates. Moreover, this offered distribution companies the possibility of signing agreements with the existing generation companies for shorter lead times and durations as a risk management tool designed to offset uncertainties in demand and the loss of free consumers. Finally, this separation prevented the existing plants from squeezing new plants out of the picture in the regulated market, thus helping ensure energy security. In total, 21 rounds of existing power plant auctions have been implemented, 19 with specific products for RES.

Adjustment auction: This auction aims to adjust the distributors' energy contracting, addressing any deviations arising from the difference between forecasts made by distributors in previous auctions and the actual demand growth. As a result of this auction, the distribution companies sign short-term contracts (from 3 months to 2 years) with the auction winner. Seventeen rounds have been implemented since 2005, none with specific products for RES.

Auctions to procure greenfield power plants, reserve energy and RES usually have a lead time to commercial operation of between 3 and 6 years. Project developers are awarded 15- to 30-year fixed tariff contracts (Figure 7).

[10] RE includes all renewable energy sources, including large hydropower plants.

Figure 7: Lead time to commercial operation of the auction projects



Source: Authors' compilation

In short, the new regulatory framework was designed to foster vast amounts of investment in the generation capacity expansion necessary to meet a fast-growing demand at the lowest cost possible (Tolmasquim, 2014). Table 6 presents the key auction information.

Table 6: Key auction information

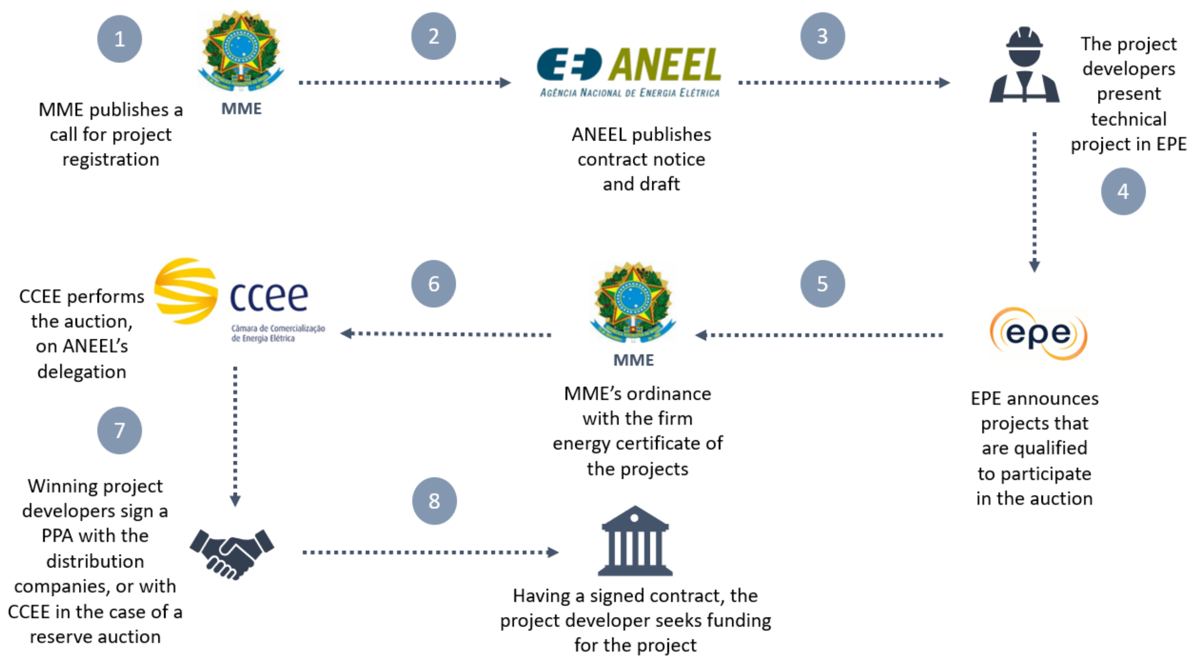
Design	**Year of introduction**	**2005**
	Frequency of auctions/rounds	82 rounds (61 rounds with specific products for RES) • 40 rounds for existing power plants, 21 with specific products for RES*) • 30 rounds for greenfield projects, including the special rounds for the hydropower plants of Santo Antonio, Jirau and Belo Monte (28 rounds with specific products for RES) • 3 rounds for only RES power plants • 9 rounds for reserve energy (all with specific products for RES)
	Currency	Brazilian Reais (indexed to local inflation)
Implementation	Policy and regulation guidelines	Ministry of Energy and Mining
	Regulator	ANEEL
	Procurer	CCEE delegated by ANEEL
	Off-taker	Distribution companies and the CCEE, in the case of reserve energy
Outcomes	New MW procured†	105.228 MW (76.862 MW from RES)
	Technology procured	Oil, coal, natural gas, wind, solar, biomass, small hydro and large hydro

Note: * Only large and small hydropower plants. † Greenfield, RES and reserve auctions.
Source: Authors' compilation

3.1. Auction design

The energy auctions in Brazil are conducted annually according to a schedule released by MME. The auction process is led by ANEEL under the guidelines of the MME. An auction committee undertakes the main auction tasks, which are distributed among different institutions (EPE, CCEE, ANEEL, MME). Once an auction is concluded, the winning generator companies sign contracts directly with distribution companies, or with the CCEE in the case of a reserve auction (Figure 8).

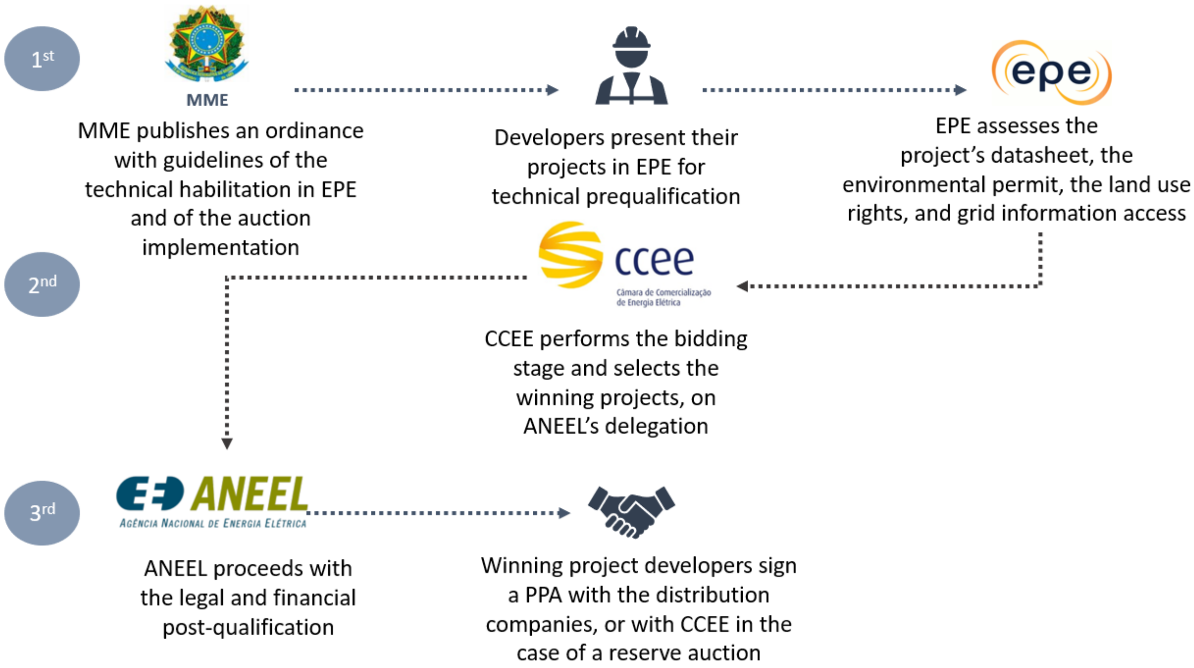
Figure 8: Auction process overview



Source: Authors' compilation

The auctions have three stages (Figure 9): the first for registration and technical prequalification; the second for bid submission and the winners' selection; and a final stage for the legal and financial qualification of the preferred bidders, performed by the regulatory agency.

Figure 9: Auction stages



Source: Authors' compilation

The first and third stages aim to reduce the risk of failure in the implementation of the project and they do not intend to rank the projects. The assessment of the required documents in stage 1 is proactive to ensure the participation of the largest possible number of projects in the bidding phase (second stage). However, considering the large number of projects registered in Brazil every auction, the qualification process was split, and the legal and economic documents of preferred bidders are evaluated in stage 3 (see section 3.1.2). The second stage encompasses the bidding and the winner selection processes (see section 3.1.3).

Since energy auctions have been regularly performed in Brazil, investors already have a pipeline of projects planned and there is no need for a long notice period to respond to the first-stage request for registration. Developers thus normally have a 30-day period during which they must respond to the call for registration. The EPE has 80 days to evaluate the projects and documents presented and to calculate the firm energy of each project.

In parallel, ANEEL opens a public consultation process for stakeholders to analyse the rules of the auction[11] and the draft contracts. Bidders have access to complete information about the auction, including the final version of the rules and contracts, the price cap and the certified firm energy requirement (physical guarantee). The information about the total demand for the auction is not disclosed in advance in order to mitigate the risk of collusion.

Winners must secure all permits and licences, reach financial closure, complete the construction of the power plant and connect it to the grid within the A-X period stipulated in the rules (see Figure 7). During the construction period, the investor can change some of the technical characteristics of their project. According to the rules of Brazil's A-6[12] auction of 2019, for example, it was possible to change the installed capacity, the turbine type and quantity of generating units, and the connection point of the power plant. Technical changes must conform

[11] Including the detailed auction process, the price rule and the winners' selection criteria.

[12] A-6 refers to the lead time of 6 years.

to environmental permits, cannot modify the energy source initially indicated, and may not compromise the fulfilment of contractual obligations assumed in the auction, such as the amount of energy and capacity negotiated, the date of commencement and the duration of the contract. Bidders in the 2019 auction were also allowed to complete the power plant construction early, and sell energy in the Brazilian wholesale market. The auction rules made it clear that all risks and costs associated with changes in the technical characteristics and the plant's commercial operations date were the exclusive responsibility of the seller and could not be passed on to the buyers.

Energy auctions and contracts have evolved over the years. In the contracts for different sources and products, different delivery obligations are designed, such as the determination of wind or PV energy generation on an annual and 4-year basis. Risk allocations are also distinct between auctions. In reserve energy auctions the risk of generation insufficiency is allocated to all consumers while in new energy auctions (greenfield, RES) the risk is allocated to generators. Table 7 shows the Brazilian auction basic design in 2019.

Table 7: The Brazilian auction basic design

Periodicity	**Annually – usually 2 rounds per year**
Project preparation	Bidders must secure social and environmental permits, land use rights and interconnection agreements to be allowed to register for bidding
Stages	
Registration and qualification	Evaluation of the required permits and documents Verification of physical coverage
Bidding	Hybrid price rule – pay-as-bid with uniform pricing (highest accepted bid)
Auction demand	
Greenfield projects	Decentralised – Distribution companies
RES	Decentralised – Distribution companies
Reserve	Centralised – MME
Energy source	Technology-specific or group of technologies
Winner selection	Only price
Lead time	Between 3 and 6 years
Risks	
Seller	Construction, operation, equipment performance risks and exposure to the spot market (in the case of the contract for energy – 'quantity contract')
Buyer	Inflation and exposure to the spot market, in the case of the contract for availability
Liabilities	
Seller	Bid bonds and surety and performance bonds
Buyer	Payment financial warranties

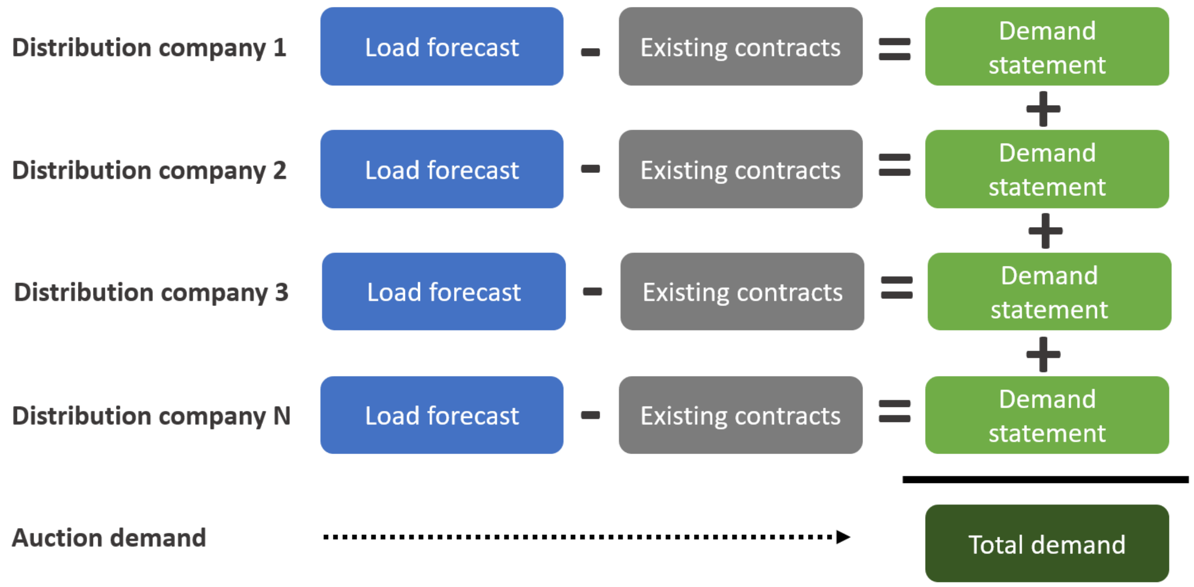
Source: Authors' compilation

3.1.1. Auction demand

As noted, electricity demand is usually constrained by the availability of energy (MWh) and not installed capacity (MW). The installed capacity is more than double the peak demand (Table 4) due to the seasonality and the stochasticity of the large hydro resources that dominate the Brazilian supply mix. Therefore, auction volumes are defined in terms of energy.

In the greenfield and RES auctions, each distribution company has to project, on an annual basis, the total amount of energy needed to supply their captive consumers for the next 3 to 6 years (Figure 10). MME prepares the auction schedule based on this information. The Brazilian government has, on average, performed at least 2 auctions for greenfield projects per year.

Figure 7: Auction demand: Centralised procurement



Source: Authors' compilation

The reserve energy auctions are meant to ensure the resource adequacy and energy security of the entire market and are conducted less frequently. The MME determines the demand for the reserve auction considering the contracting level of the distribution and free consumers, the balance among the different energy sources and the evaluation of possible deviations between the physical coverage granted to the power plants and the real firm energy available to the system. The auction demand for all auctions (greenfield, existing power plants, RES and reserve) is not disclosed to the bidders.

The auction demand is not sensitive to the price. Still, it can be reduced at the start of the auction by the use of an endogenous rationing mechanism, according to the following equation:

$$Final\ demand\ = min\left(Initial\ demand;\ \frac{Initial\ offer}{Adjustment\ parameter}\right) \quad (1)$$

Where:

Final demand: The demand that will be procured in the auction.

Initial demand: The summation of the demand requested by the distribution companies or by the MME, in the case of the reserve auction.

Initial offer: The summation of the amount of energy offered by the bidders.

Adjustment parameter: An integer number equal to or higher than 1, set by the MME before knowing the total offer to ensure a minimum level of competition in the auction.

Considering that the Brazilian auctions usually procure energy contracts for a specific technology, or group of technologies, the same methodology described above was used to adjust the demand for each kind of contract. The methodology of endogenous rationing, as described above, is reported to produce suboptimal results (both theoretically and in practice) if used to artificially increase competition or reduce final price (Hanke & Tiedemann, 2020). This is not the case in the Brazilian approach, since the mechanism aims to increase demand uncertainty to limit potential collusion among generators. Therefore, the adjustment parameter is discretionarily chosen by the MME before the second stage (the bidding process) begins and is usually equal or near to 1. On the other hand, considering the usual large number of initial offers in the Brazilian auctions, the mechanism has rarely been triggered.

Moreover, the MME has the power to split the demand in the beginning of the auction among technologies and energy sources based on other criteria, such as political targets for renewable sources and energy security.

3.1.2. Qualification criteria and process

The qualification process aims to ensure that only committed and highly capacitated bidders are selected and that projects have a high likelihood of being built on time. Only bidders who meet the technical, environmental, social, legal and economic criteria of the qualification process can sign the contracts awarded in the auctions. Unfortunately, the evaluation of all requirements may be time-consuming and costly for both bidders and auctioneer.

Therefore, to reduce its transaction cost, the Brazilian auctioneer divided the tender into three stages (Table 8). The first is a prequalification stage focused on the technical, social and environmental criteria of the projects. In the second stage, bidders must provide bid bonds and price bids.

During the prequalification process, the EPE also calculates the firm energy certificate of the submitted project. As explained above, this is the foreseeable generation that, once approved by the MME, represents the maximum amount of energy that the project can commit to with energy contracts. The firm energy of wind and PV projects corresponds to the annual value of energy that could be generated with a probability of occurrence equal to or greater than 90 per cent (p90) and 50 per cent (p50), respectively. The generation data used must be certified by independent entities and the use of a less stringent criterion for solar PV can be understood as a form of incentive.

The last step is focused on the legal, economic and financial prerequisite for the investors and, therefore, is performed only after the conclusion of the bidding selection of the preferred bidders. This approach is used in auctions and tenders of all sectors in Brazil. It refers to the fact that legal and financial requirements are more subjective and more likely to be disputed by bidders. Therefore, unbundling the qualification process avoids the risk of dealing with many appeals and challenges of qualification documents from developers with no competitive bid.

Table 8: (Pre)qualification criteria

Evaluation criteria	Stage 1 Prequalification	Stage 2 Bidding	Stage 3 Qualification
Land (acquisition and use rights)	✓	x	x
Social and environmental permits	✓	x	x
Grid connection assessment	✓	x	x
Technical criteria and evaluation	✓	x	x
Bid bond	x	✓	x
Price	x	✓	x
Legal criteria and evaluation	x	x	✓
Financial criteria and evaluation	x	x	✓

Source: Authors' compilation

The EPE usually concludes the prequalification process in 80 days, while ANEEL completes stage 3 in 10 days. There is no qualitative assessment of the information provided, and the process in the first and last stages is not intended to rank the projects or to contribute to the winner selection process, since this is based only on price. However, a project that does not comply with the qualification criteria will not be allowed to join the bidding process of the second stage or to sign the contract, depending on the case.

Once the last qualification phase has been completed, the winning bidders must reach the financial close of their projects within 6 to 12 months. The commercial operation date depends on the auction type and the investor's strategy. Some PV and wind plants that win the A-6 auction start commercial operation before the date established in the contract and sell the energy in the free market.

The following unpacks the qualification criteria outlined in Table 8.

Site selection and land use rights

Bidders are responsible for project site selection and preparation, which includes the acquisition of land use rights. Bidders are required to provide the coordinates of the proposed project site and proof of land acquisition or land use rights, such as a notarial lease or title deeds for the project site; an unconditional land option, sale or lease of land agreement; or a conveyancer's certificate.

However, the MME and ANEEL engage with developer to define the sites of hydropower to secure the optimum use of hydraulic potential of the entire river, and, for strategic large hydropower plants, the EPE may prepare studies and reports for site selection and may apply for the preliminary environmental permit.

Social and environmental permits

Bidders need to provide an environmental permit and a social and environmental impact assessment, detailing the change in land and water use, and the impacts of the generation process on local communities, wildlife, scenic view and other relevant factors.

The Brazilian process for environmental permitting is decentralised and multidisciplinary. According to the type of activity involved and extent of the expected environmental impacts, the administrative process can be performed by environmental agencies and public authorities (accountable for public policies on health, jobs, and historical and archaeological protection) at municipal, state or federal level. The network of environmental agencies and public authorities form the Brazilian National Environmental System, which is coordinated by the Ministry of Environment (*Ministério do Meio Ambiente*, or MMA) and has a deliberative body (*Conselho Nacional do Meio Ambiente*, or CONAMA) to establish the directives of the permitting process, according to Resolution CONAMA 237/1997.

Environmental permitting starts with the investor registering the project with the environmental agency of jurisdiction over the location and the kind of economic activity of the project,[13] with the presentation of an activity description sheet and an environmental impact declaration. After receiving and processing the information registered by the investor, the environmental agency prepares the Term of Reference for the permitting process, which establishes if the project will follow a normal or a simplified course and defines the scope of the environmental studies and report that must be presented by the investor to obtain the permits.

[13] As a general rule, most RES projects will be under state jurisdiction.

In the normal process, investors must secure 3 sequential permits: the preliminary permit (*Licença Prévia*), the construction permit (*Licença de Instalação*) and the operational permit (*Licença de Operação*).

The preliminary permit approves the environmental feasibility of the project and establishes the conditions (additional studies or countermeasures to mitigate the environmental impact) for the construction permit. Therefore, it is the most complex and time-consuming permit. Before securing the preliminary permit, the investor must prepare a full environmental impact assessment and its respective report, and conduct public hearings with the local communities that may be affected by the project.

In the simplified process, the investor has to prepare only a simplified environmental report to obtain the construction permit directly.

In both cases, the investor must comply with the construction permit conditions to receive the operation permit and conclude the environmental licensing.

Grid connection assessment

Bidders must also provide a grid connection assessment indicating the need for 'shallow connection works' (works for the bidder's project connection to the system) and the approval of the ONS, indicating the feasibility of the intended connection. Once awarded preferred bidder status, developers must sign connection contracts with the transmission company and contracts for the use of the transmission grid with the ONS. The transmission tariffs charged by the ONS include a fixed and a locational component that developers need to consider in their bid. The preferred bidder is also responsible for covering the costs of the shallow connection works. In contrast, the transmission company covers the costs of the deep connection works that will be incorporated into the tariffs and divided among all users of the transmission system.

In the case of connection delays, the winning bidder is obliged to procure energy in the market to cover its contractual obligations, except in the cases of *force majeure*.

Technical criteria and evaluation

For the technical evaluation, bidders must provide:

- Small and large hydropower plants: a basic engineering project[14] approved by ANEEL containing all the necessary technical specifications for the estimation of cost and construction time, information on investment and debt to the project;
- Wind farms: the certification of anemometric measurements and the estimate of the electric energy production associated with the park, issued by an independent certifier; and
- Photovoltaic plants: the certification of solarimetric data, and the forecast for electricity production, issued by an independent certifier.

For wind and PV plants the bidders must also provide the project description memorial. The memorial presents the primary information of the project. For example, in the case of wind energy, the project description should include, among others, the following topics: general characteristics of the project (location and access, available infrastructure, wind potential and climatic conditions and broad characterisation of the land), connection system characteristics (attributes of the elevating electrical substation, description of the project connection) and project drawings.

[14] The basic engineering project, also called basic project or preliminary project, is the set of documents that define the project and its most favourable cost in a given context.

Legal criteria and evaluation

After the bidding process, the winning bidders still must pass through a final legal and financial qualification process.

As part of the legal qualification process, bidders must provide the project ownership structure and proof of shareholders' fiscal good standing and compliance with labour regulations. In the case of projects with foreign companies or pension and investment fund shareholders, it is also required to commit to establish an SPV ahead of receiving the authorisation to be an IPP. No term sheets from lenders are necessary.

Financial criteria and evaluation

For financial qualification, a bidder must demonstrate its capacity of investment by providing the company (or shareholder, in the case of an SPV) audited balance sheet, statements and other accounting and fiscal records of the last year.

Price cap

The Brazilian auctions make use of price caps both as an instrument to protect consumers from abuse of market power and collusion and as a signal to developers that want to prepare projects to join future auctions. The price cap is calculated by EPE and approved by the MME considering the fixed and variable costs of each energy source, the duration of the contracts, the taxes, and the regulatory WACC for generation via a cash flow assessment. The price cap is public, specific for each procured product or energy source and is disclosed at least 30 days before the bidding stage. Table 9 presents the price caps used in 2018 and 2019.

Table 9: Brazilian price caps in 2018 and 2019

	Auction A-6 2019 10/18/2019	Auction A-4 06/28/2019	Auction A-6 2018 08/31/2018	Auction A-4 04/04/2018
Large hydro	US$69.68/MWh	US$71.64/MWh	US$73.79/MWh	US$85.34/MWh
Small hydro	US$69.68/MWh	US$71.64/MWh	US$73.79/MWh	US$85.34/MWh
Wind	US$46.21/MWh	US$51.74/MWh	US$57.76/MWh	US$74.78/MWh
PV	US$51.10/MWh	US$68.66/MWh	-	US$91.50/MWh
Biomass	US$71.39/MWh	US$77.36/MWh	US$78.37/MWh	US$96.48/MWh

Source: ANEEL (www.aneel.gov.br, accessed June 2020)

Bankability

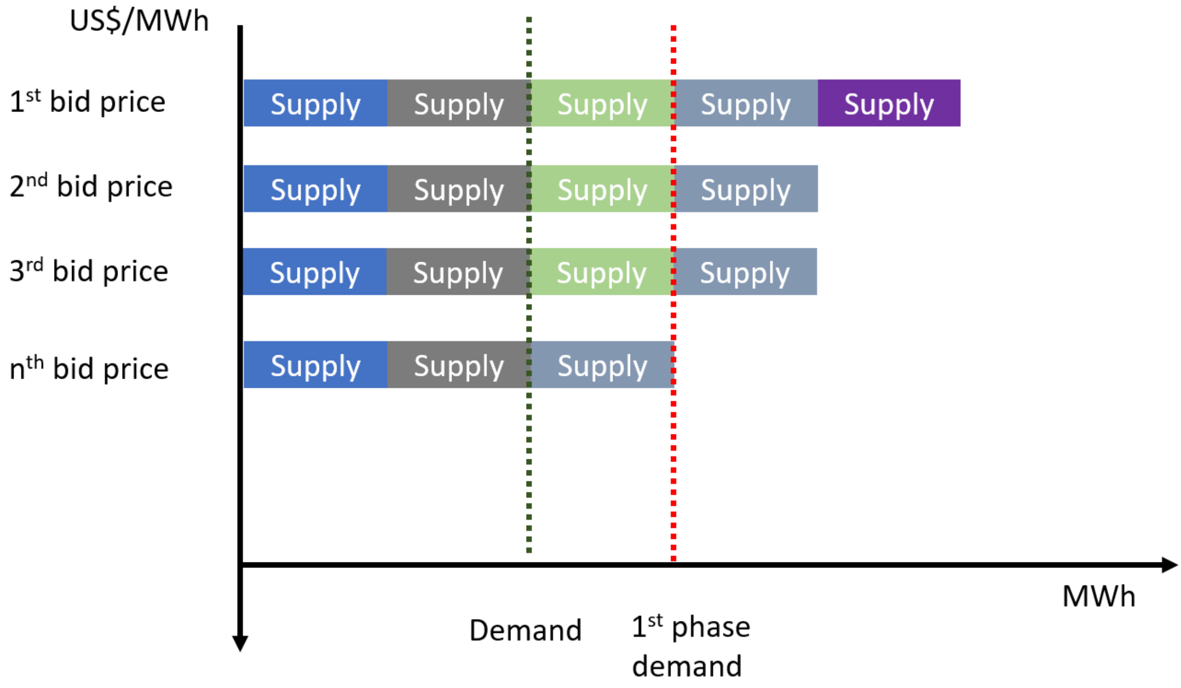
The MME designed the first draft of the PPAs for greenfield projects (in 2004) in close collaboration with the Brazilian Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social*, or BNDES), the main funder for investment in infrastructure in Brazil, with the purpose to have a contract suitable to back the loan needed to develop the project with its expected incomes (project finance model). Therefore, the PPAs are standardised and have explicit clauses with the conditions and procedures for the change of the control of the project and for the exercise of the step-in right in which the lender intervenes in the execution and administration of the project to ensure its completion.

3.1.3. Bidder ranking and winner selection

The regular auction procedure is a hybrid model that occurs in two phases. The first phase is a descending-clock auction, or Dutch auction, of uniform price, that starts with a ceiling price defined by MME (Figure 11). Bidders indicate how much they are willing to supply at this price. The auctioneer then lowers the price until the desired supply level is met, plus a certain margin. The auction uses an inflated demand level stimulate competition in the second phase.

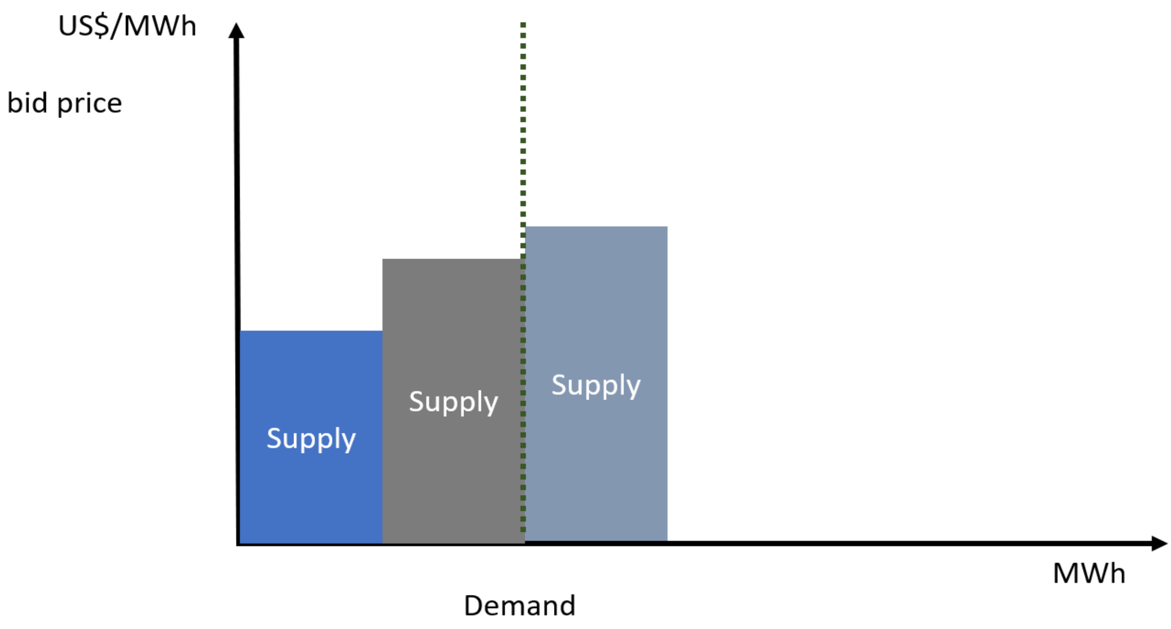
Phase 2 operates as a final pay-as-bid round for the winners of phase 1. Remaining bidders offer a final sealed price, which cannot be higher than the price disclosed in phase 1. The clearing price is determined when supply equals demand, and the winning bids are those lower than the clearing one (Figure 12).

Figure 8: First phase: Uniform-price auction



Source: Authors' compilation

Figure 9: Second phase: Pay-as-bid auction

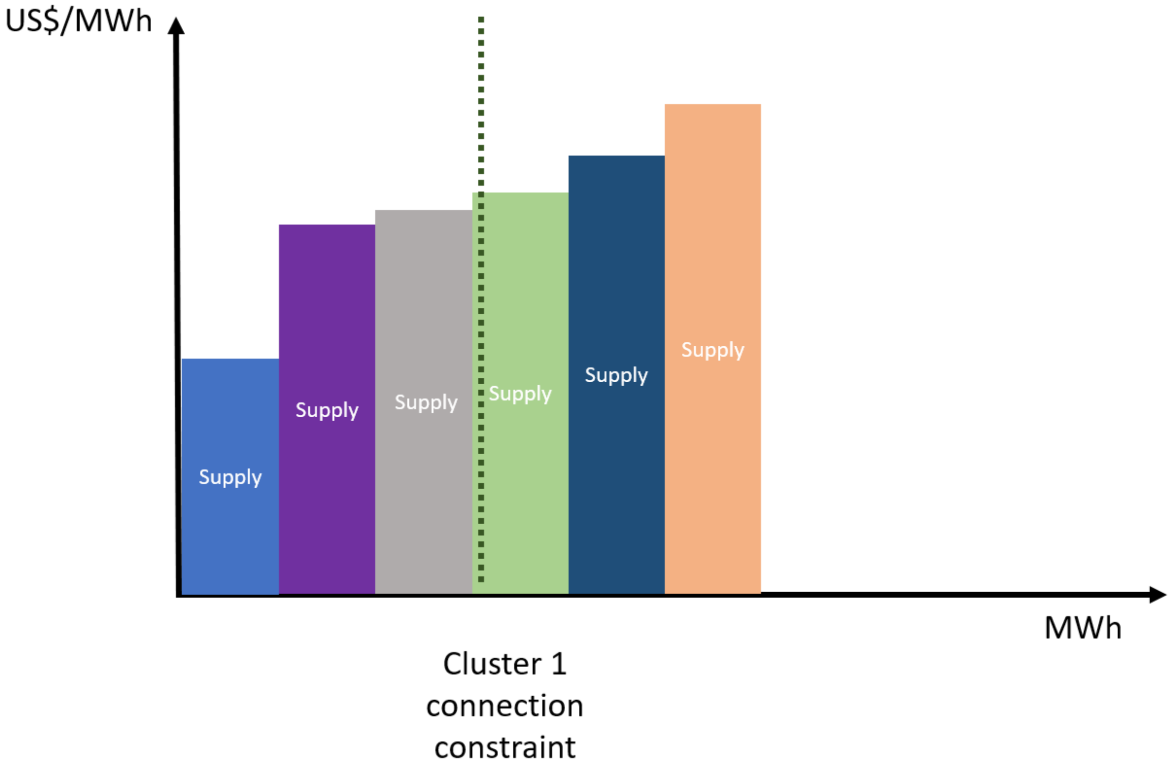


Source: Authors' compilation

For simplicity, winner selection under the Brazilian auction scheme is based exclusively on price.

Due the increase in construction timelines of transmission lines in Brazil and the uncertainty about the auction's winners' location, since 2013, auctions with a lead time shorter than 5 years have been performed with a different approach. This new design includes a preliminary phase to select the projects with connection feasibility through competition among projects with the same connection point. In the preliminary phase, bidders thus submit a single bid with price and quantity for each project. The auctioneer classifies bids according to their price at each connection point following the discriminatory price methodology (Figure 13). Projects that exceed the 'transmission margin', calculated by EPE and ONS for each connection point indicated by the registered projects, are excluded from the first and second phases of the auction. The winners then engage in the general auction process following the methodology described above (Figures 11 and 12).

Figure 10: Preliminary phase for transmission dispute: Pay-as-bid auction

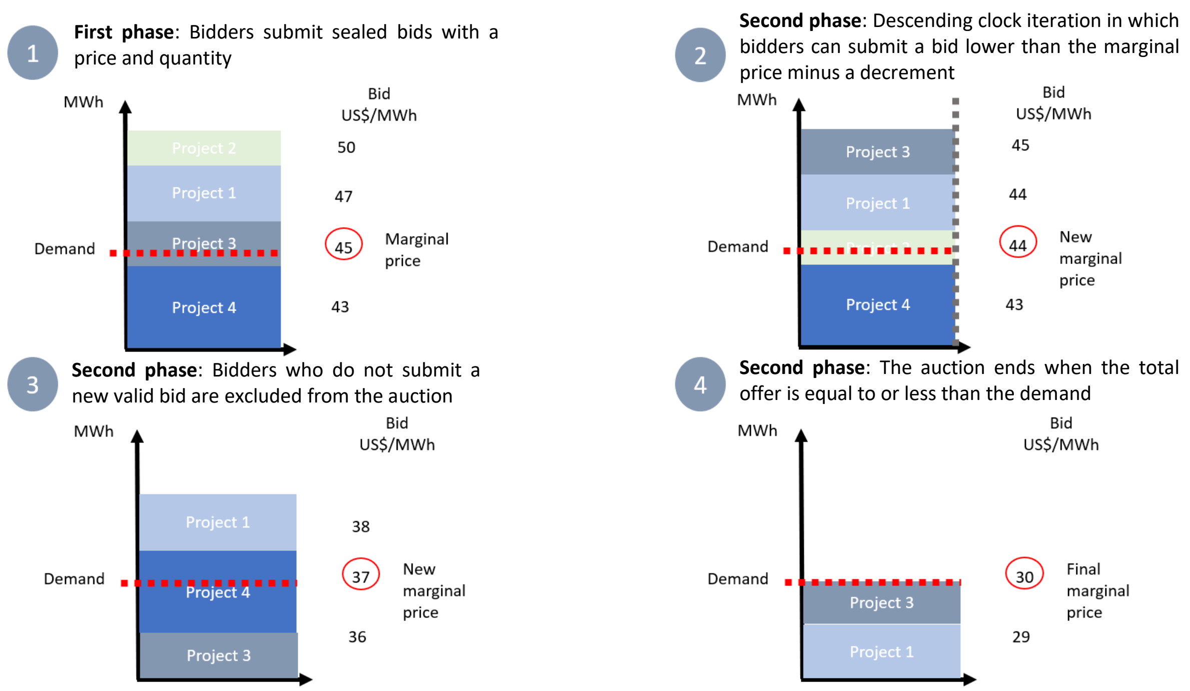


Source: Authors' compilation

From 2017, the Brazilian auction programme again changed the bidding process. The new methodology is called a continuous trade reverse auction. The new design also has 2 phases, but in this first phase, bidders submit sealed bids with a price and quantity. Bids are evaluated by price, and the auctioneer classifies the 'temporary winners' as the lowest bids up to the market-clearing quantity (demand), while all other bidders are considered temporarily disqualified. The second phase is a descending clock iteration of 3 or 5 minutes (depending on specific auction rules), in which any temporarily disqualified bidder can replace a temporary winner by submitting a bid lower than the marginal price minus a decrement. The decrement (the minimum difference between the marginal price of temporary winning bids and the new bids) is set by the auctioneer prior to the auction (Hochberg, 2018).

The price presented in the first phase (during the transmission point competition) cannot be increased in the second phase, and the bidders remain limited to their prior bid (price and quantity) until the current bidding price of the second phase reaches their price. At that moment, the bidders may submit a new bid with a lower price or remove their offer from the auction. The auction closes when the total supply has met the auction's demand, and the outcome can be a mix of uniform and discriminatory price, depending on how fierce the competition for the first phase was (Figure 14).

Figure 11: Continuous trade reverse auction (since 2017)



Source: Authors' compilation, based on CCEE

3.1.4. Buyer and seller liabilities

3.1.4.1. Financial prequalification and penalties

Bid, surety and performance bonds

The bidders with projects prequalified in stage 1 must provide a bid bond of 1 per cent[15] of the estimated investment. The purpose of the bid bond is to cover the risk that the submitting bidder might not abide by its offer. The bond will be executed if the awarded bidder does not sign the contract or does not present a surety and performance bond. The bid bond is also returned if the project does not win the auction.

Bidders must also provide a surety and performance bond covering the construction risks. The surety and performance bond is retained throughout the construction of the power plant. Its initial value must cover 5 per cent of the investment. The reduction in the surety and performance bond has varied over time, depending on the energy source and on the year. For instance, in the A-6 auction performed in 2018, wind was allowed to reduce the bond as follows: beginning of concreting the bases of the generating units – 10 per cent reduction in the

[15] The value corresponds to the highest amount allowed by Act 8.666.

financial guarantee; start of the assembly of the towers of the generating units – 40 per cent reduction; start of operation and testing of the first generating unit – 60 per cent reduction. However, in the last A-4 auction performed in 2019, only small and large hydro were allowed to reduce the bond by 25 per cent once the construction work starts, while all the other energy sources must retain the entire bond until commercial operation. The motivation for this change is not clear.

3.1.4.2. Risk allocation and penalties

The Brazilian auctions can procure for 2 categories of contract, depending on the allocation of the generation risk. The first category is the contract for 'energy quantity', in which the IPP bears the entire generation risk, including the imbalances caused by centralised dispatch orders. The 'energy quantity' contract is a standard financial forward contract, in which generation companies receive a fixed amount from their distribution counterparts and the difference between the contracted amount and the amount produced or consumed is settled on the spot market. Like any term contract, these hedge agreements protect sellers against low prices on the short-term market (more frequent) and purchasers from high prices (less frequent but very steep).

The second type of contract is for energy availability, and the IPPs bear the ordinary risks of equipment reliability and performance but are not obliged to procure energy in the market when they are not dispatched. The 'availability contract' was initially designed to complement thermal power plants. It transfers the 'systemic' risks (hydrology), which cannot be managed by individual investors, to consumers. In the case of thermal power plants, it avoids the situation in which the investor hedges against infrequent dispatch due to long periods of good hydrology by overpricing energy in the auction. It resembles the capacity mechanism known as a 'reliability option' or the financial concept of 'call options' since the IPPs receive a fixed payment in exchange for the obligation that their generation capacity will be available when some given strike price is reached or when the system needs to dispatch the power plant out of merit order, due to transmission congestion, system reliability or other reasons. In other words, the distributor pays a fixed revenue for exercising the option and the variable cost is the strike price. Whenever the spot market price exceeds the strike price, the option buyer (distributor) exercises the option right (generation).

Since 2018, MME has changed wind power plant contracts from availability to quantity. It did the same with the solar energy contracts in 2019. Since then, the wind and solar plants have to buy electricity in the spot market if their production is lower than the amount sold in the auction.

ANEEL also modified contracts in 2019 to take wind and solar energy seasonality into account. Up until that point, a project's total annual energy generated was adjusted monthly according to the generation profile. For instance, in the Northeast region the winds blow more between May and November; the power plants could choose to generate more in this period and less in the other months, as long as the total annual generation meets the contract amount. After 2019 energy production must follow the distribution load seasonality. So, generation seasonality risk has passed from the consumers to the generator.

Considering that the auctions procure greenfield projects, several construction and operational risks need to be considered and contractually allocated. If a project fails to comply with the contractual timetable and performance standards, it has to procure an equivalent amount of energy with a price rebate. The price rebate is set according to the lowest value among (i) the contractual price reduced by 15 per cent; (ii) the average of the spot price in the month; and (iii) cost of the energy procured by the sellers in the energy market to fulfil their contractual obligation. Non-compliance may also result in the issuing of penalties such as fines, the early termination of the contract,[16] and the temporary impediment to participate in further auctions and to contract with the government for up to 2 years. Most of the environmental and social, technical and business risks are allocated to the developer, and all exceptions are expressly defined in the contracts.

Developers are protected against political and regulatory risks, including change in taxation, inflation and, in the case of fossil power plants, exchange rates and variation in international fuel prices. The price of the energy is indexed to the consumer price index. Brazil has persistent and volatile inflation rates, and, in this context, indexing seeks to maintain the real value of the seller revenues along with the cash flow. Thus, the feasibility and risk analysis of the project, especially for obtaining funding, can be accomplished without the need for forecasts about expected inflation. The allocation of the inflation risk to consumers reduces the value of bids and the final price of the auction.

Undue delays in the environmental permitting processes are compensated for by extensions in contractual duration.

Finally, until 2015, if the sellers proved that the power plant had been completed and was prevented from generating because of delays in deep connection works, their contractual obligations were suspended. However, since then, the grid connection risk was allocated to the sellers. The shift in the transmission risk allocation followed changes to the approach for transmission planning and expansion. Until 2015 the EPE used the outcome of the energy auction to evaluate the transmission solution with minimum global cost and to consolidate the transmission expansion plan that will be used by the MME and ANEEL as the reference for the transmission auctions. However, over time power plants began to be built further and further away from the load, making transmission lines longer and environmental licensing more complex and time demanding. As a result, one started seeing more power plants completed before the necessary transmission works.

MME and EPE consequently started planning transmission expansion in advance, contracting transport corridors for the development of sites with energy potential before the energy auctions. In such a context, once the generator can evaluate but not manage the risk of connection delay, the change in the allocation of the transmission delay risk aims to incentivise developers to bid projects that will be connected to existing transmission points or, at least, to points already under construction. The introduction of a 'transmission margin' competition before the auction (see section 3.1.3) further reduces the transmission delay risk.

3.1.5. Securing the revenue stream and addressing off-taker risk

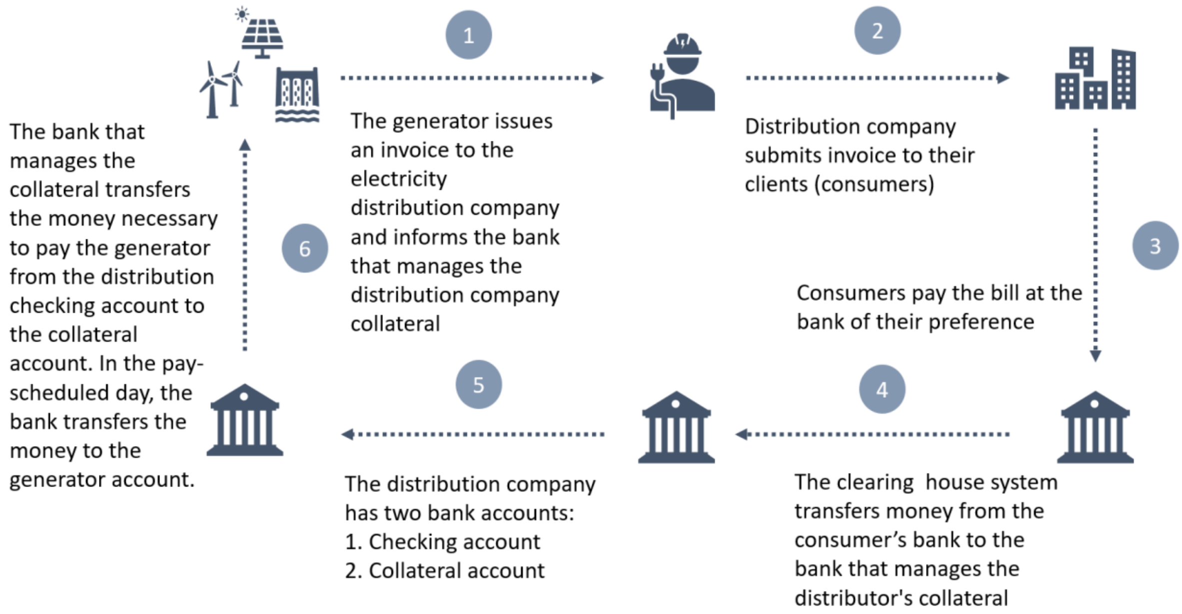
Investor confidence can be significantly improved through the provision of payment guarantees by off-takers, resulting in more competitive offers and higher realisation rates.

In the Brazilian scheme, the energy may be contracted by distribution companies or procured directly by the MME, in the case of reserve energy. In the first case, total demand is aggregated, and each preferred project signs off-take contracts with each distribution company, thereby reducing payment risks through a portfolio effect. Moreover, the distribution companies include the energy cost in Component A (Figure 4) of the distribution tariffs and transfer it to the regulated consumers. In the second case, reserve energy is funded by an energy levy that is collected among free and regulated consumers.

[16] In case of long delay in completion. The early termination can be asked for by the developer, the off-taker or be a discretionary decision of ANEEL, respecting the right of all sides to be heard.

To secure the revenue stream and to limit off-taker risk, the distribution companies must provide an accounts receivable assignment to the IPP, meaning that revenue collected from end-users will be deposited into a specific bank account, under the supervision of a managing bank, which will ensure that energy purchase contracts will be paid before the funds are made available to the distribution companies (Figure 15).

Figure 12: Accounts receivable scheme



Source: Authors' compilation

Finally, considering the complexity of the contracts and the market uncertainties, the Brazilian contracts establish arbitration as the primary mechanism for dispute settlement. The arbitration instrument is usually faster than the judicial and administrative courts and ensures that the arbitrators will be experts.

3.2. Auction implementation

Auction success, in general, is as much dependent on good auction design as on bidder trust in the auction process. The presence of a mandated, credible, well-capacitated and well-resourced agency responsible for managing and implementing the auction process is a critical success factor. Coordination among government entities is also essential to the success of the auction. The inputs of various government departments and agencies impact the process of project prequalification, mainly because developers need to secure preliminary environmental permits and land use rights, which means a long and difficult process of engagement with federal, local and state-level authorities (Figure 16).

In the Brazilian scheme, the auction programme is implemented by four institutions. The MME is responsible for setting the guidelines, the schedule and the design of the auction, including bidding rules and winning selection criteria, and for issuing the call for projects registration.

The EPE is responsible for the prequalification stage, assessing the registered projects' datasheet and the documentation for land use rights and environmental permits. The information collected by EPE during the prequalification process is used to prepare a technical note on the price cap of the auction and the maximum amount of energy each project will be allowed to sell. The EPE technical notes support the MME decision about those issues.

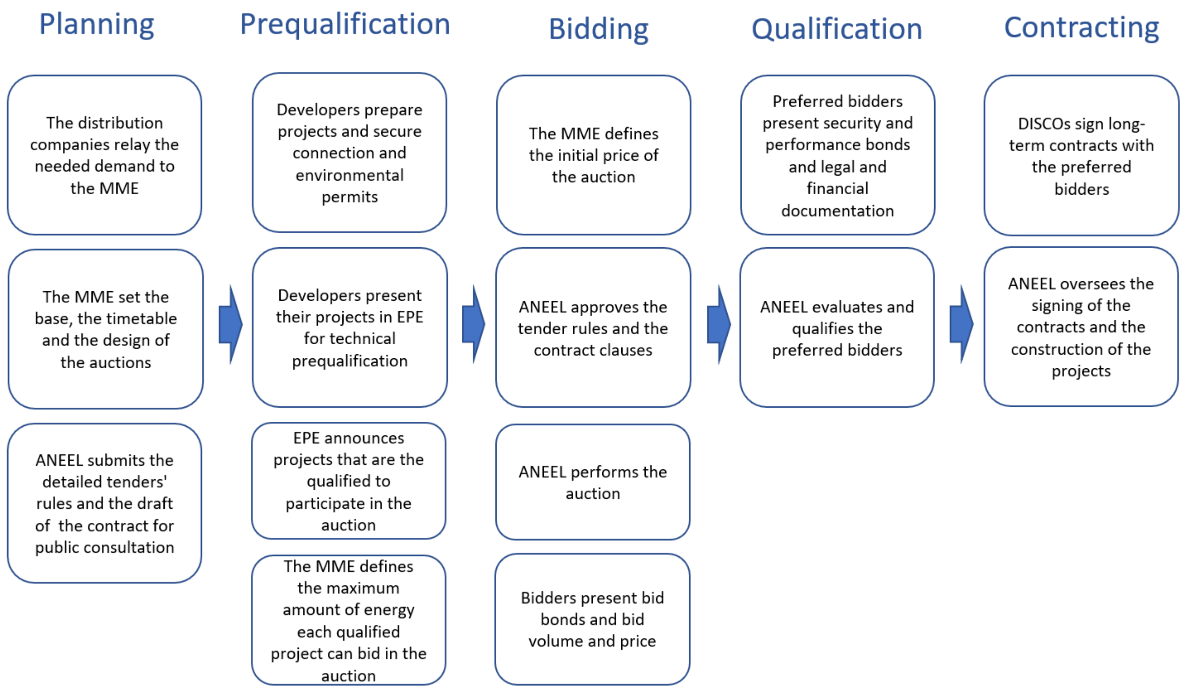
ANEEL prepares the draft contracts, performs the auction with the technical support of the CCEE, conducts the technical and financial qualification of the preferred bidders, and oversees the signature of the contracts and the completion of the projects in due time. The energy contracts are signed by the distribution companies and the reserve contracts by the CCEE.

The role of each institution is determined by Decree 5.163, but reflects the division of responsibilities established by the Brazilian regulatory framework, especially by Acts 9.427 and 10.848, that creates ANEEL and regulates the production and procurement of energy to the regulated consumers.

The designed process is complex and time-demanding, but has been performed with a high level of transparency (every auction is preceded by a public consultation), and predictability, contributing to an increase in bidder confidence in the process and in political support.

The auction programme is funded by the buyers and sellers proportionally to the contracted energy. If the auction is cancelled or performed without the sale of energy, the auction costs will be paid entirely by the buyers, in proportion to their announced demand. The cost of each auction is, however, low and covers only the expenditures of the CCEE, since MME, ANEEL and EPE are funded by public budget. The total cost of the 30th greenfield auction, performed on 18 October 2019, was, for example, US$13 000.

Figure 13: Brazilian auction implementation scheme



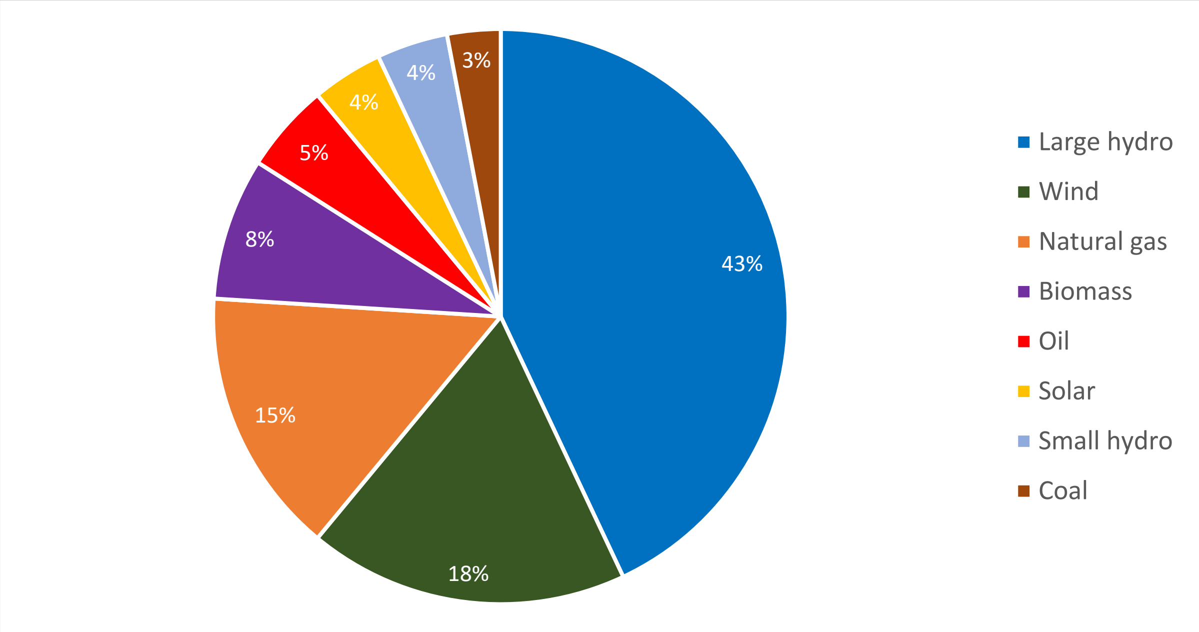
Source: Authors' compilation

Finally, the auctions are performed electronically using a platform developed by the CCEE. The integrity of the process, the outcomes and the security of the information exchanged during the auction are audited by an independent third party.

4. Results

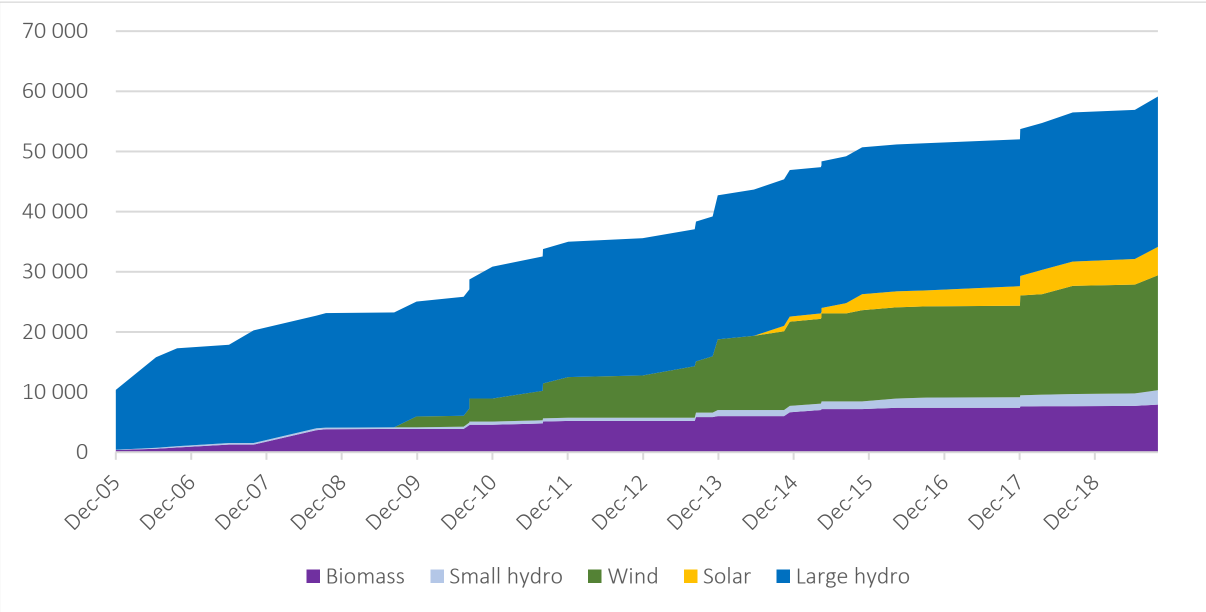
Brazil's regulated auctions contracted 9.571 TWh of energy between December 2004 and October 2019, of which 8.180 TWh was from new (greenfield) power projects, adding 105.2 GW (76.8 GW of RE) to the grid (Figures 17 and 18).

Figure 14: Brazilian auction outcomes: Contracted capacity



Source: CCEE (www.ccee.org.br, accessed June 2020)

Figure 15: Brazilian auction outcomes (MW): New capacity of RES



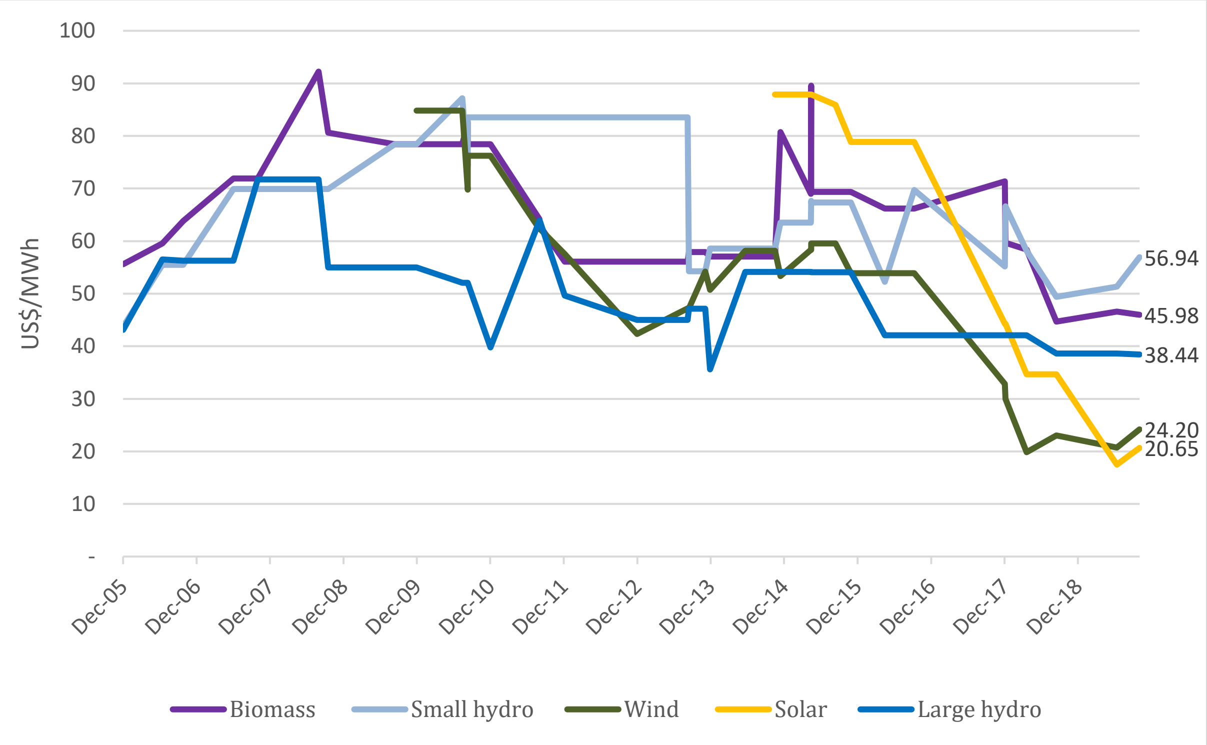
Source: CCEE (www.ccee.org.br, accessed June 2020)

The auction scheme also fosters the growth of non-conventional renewable sources in Brazil. This process was accompanied by an initial increase in the price of biomass and small hydro until December 2009, when the competition of wind power plants reversed the trend. The competitiveness of wind technology is partly explained by the worldwide reduction of the equipment costs due to technological advances and economies of scale, but also reflects the development of local investment capacity. Additionally, the period was characterised by a gradual reduction in the cost of capital in Brazil.

In 2013, however, the wind price trends reversed again, and wind energy prices returned to the initial US$55/MWh level in November 2015, while the biomass price reached a peak of US$89/MWh in April 2015 (Figure 19). Two effects contributed to the price hike. First, the growth in the number of projects facing construction delays and the bankruptcy of a large local equipment provider increased investors' risk perception. Second, the return of inflation acceleration in Brazil also reversed the downward trend in the basic interest rate (SELIC), making financing scarcer and costly.

Finally, the entry of solar PV energy in the market and the return of the interest rate reductions from 2015 gave new impetus to the reduction of energy prices in Brazil (Figure 19).

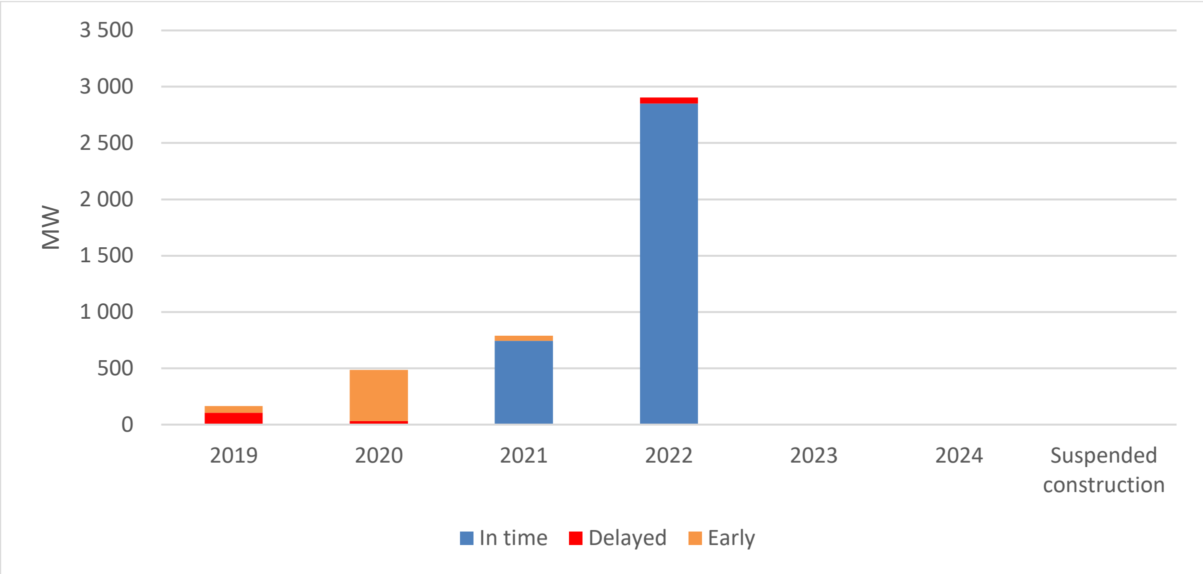
Figure 16: Brazilian auction outcomes: Prices



Source: CCEE (www.ccee.org.br, accessed June 2020)

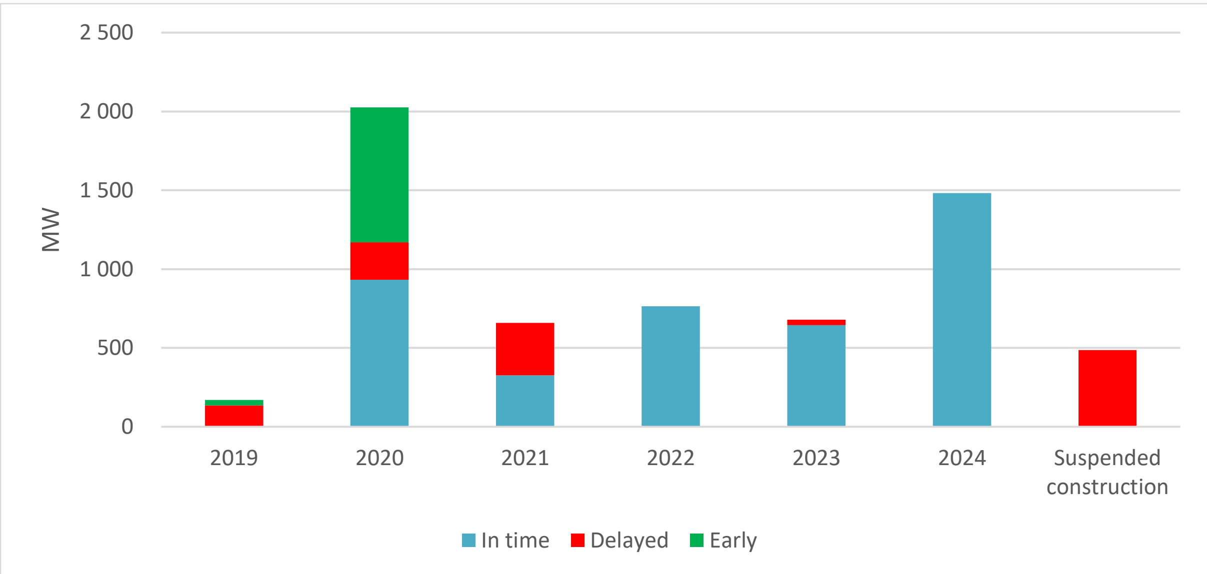
On the other hand, the emphasis of the Brazilian scheme on procuring new power plants implies a residual risk of delay or bankruptcy. Figures 20, 21 and 22 present the situation of 374 power plants in construction in October 2019 and show the capacity (in MW) deployment to comply with the contracted timetable. About 7 per cent of solar PV, 30 per cent of wind and 50 per cent of biomass power plants are delayed. More relevant, 14 per cent of wind and 12 per cent of biomass power plants do not even have a probable date of completion, indicating a strong likelihood that the contracts will be terminated.

Figure 17: PV power plants: Compliance with construction timetable



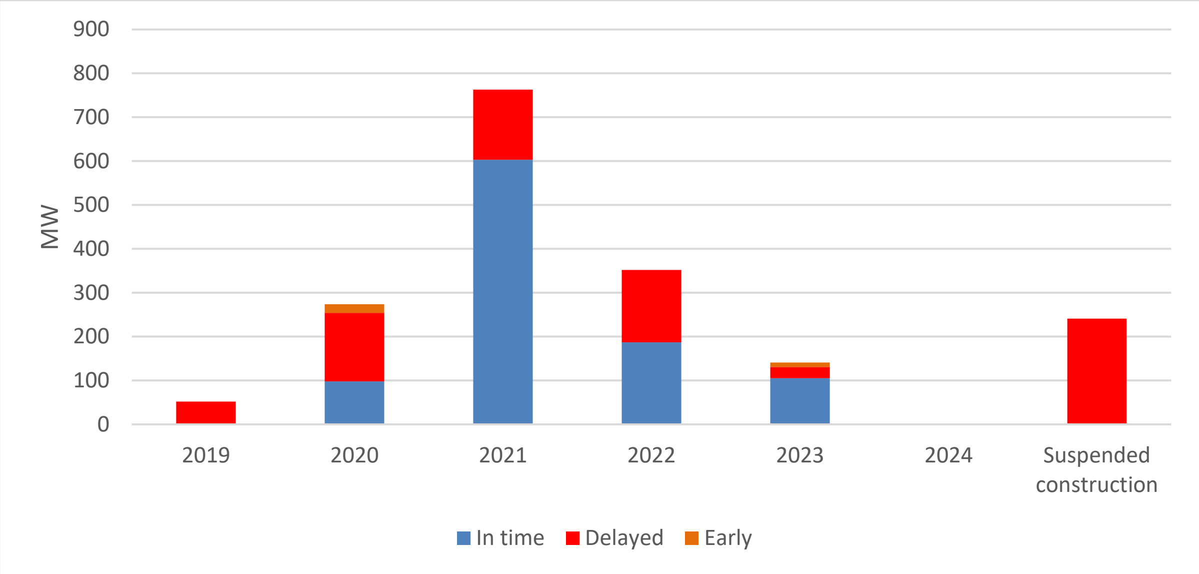
Source: ANEEL (www.aneel.gov.br, accessed June 2020)

Figure 18: Wind power plants: Compliance with construction timetable



Source: ANEEL (www.aneel.gov.br, accessed June 2020)

Figure 19: Biomass power plants: Compliance with construction timetable



Source: ANEEL (www.aneel.gov.br, accessed June 2020)

The leading causes of delays are construction cost overruns (18 per cent); the unanticipated difficulty of obtaining financing (26 per cent); the difficulty obtaining construction, operation and environmental permits (18 per cent); delays in connecting to the transmission system (20 per cent); and problems with equipment suppliers (12 per cent).

As previously discussed, project realisation delays and contract termination have plagued the Brazilian auctions in recent years (see section 3.1.2 and 3.1.4.2).

To reduce the environmental risk, the Brazilian auction scheme has a prequalification phase where the investors must present, at least, a preliminary environmental permit. However, some features of the Brazilian environmental licensing process make it very long, complex and uncertain, and securing the preliminary permit does not guarantee that the construction and operation permits will be issued. Indeed, a report by the legislative consultancy of the Brazilian Federal Senate pointed out the main flaws of the environmental licensing process (Hofmann, 2015):

- The environment impact assessments and reports' extensive focus on the negative impact of the project, ignoring the positive externalities;
- The excessive imposition of conditioning factors and mitigating actions by the public authorities;
- The multiplicity of actors with discretionary power;
- The frequent judicial control;
- The absence of a strategic environmental policy;
- The scarcity of systematised environmental data and public information; and
- The excess of bureaucracy, and the use of vague terms such as 'low environmental impact' and 'directly or indirectly affected area' in the resolutions and guidelines provided by CONAMA and MMA.

Finally, despite following all of the rules, the environmental, construction and operation permits are not bonded. Thus, any public authority involved in the licensing process may request further studies and revise its previous understanding regarding the permits at any time, especially if an environmental or archaeological finding is identified. Thus, environmental risk in Brazil is very relevant and difficult to mitigate.

Transmission connection challenges were the result of the previously discussed approach to transmission system expansion planning and tendering, which initially would only commence after energy auctions were finalised. It is hoped that the new approach outlined in sections 3.1.2 and 3.1.4.2 will help to address this bottleneck.

Finally, the company IMPSA founded Wind Power Energia (WPE) in December 2006 to produce wind and hydroelectric equipment in Pernambuco. At the end of the first semester of 2014, the economic and financial situation of WPE began to deteriorate. After delays in the payment of international debts, on 5 December 2014, WPE requested judicial reorganisation to avoid bankruptcy. The immediate outcome was the interruption of the delivery of all contracted equipment, amounting to an installed capacity of 1 580 MW, which resulted in the construction delay of 26 projects totalling 579.2 MW (ANEEL, 2016).

5. Lessons learned and recommendations

The Brazilian auctions have been successful in scaling up private investment and the deployment of RE at fair prices, confirming that auctions are effective and efficient at revealing prices under uncertainty. Nevertheless, contracting power plants in the project phase involves risks related to cost overruns, construction delays and price volatility that cannot be completely mitigated. Brazil's experience highlights important lessons on how these risks can be dealt with, both in terms of how auctions are implemented as well as designed.

5.1. Auction implementation

Effective and efficient auctions start with a comprehensive regulatory framework. The responsibility of each institution that takes part in the auction programme must be clearly defined and understood by all stakeholders. The institutions must act in cooperation and under the coordination of a single organisation that clearly defines the role and the boundaries for each institution. Second, institutions must be adequately funded and provided with human resources.

Participating in auctions has significant transaction costs, including the cost of preparing and developing the project, obtaining permits and providing bid bonds and other financial warranties. If auctions are not part of a periodic and predictable process, the risk of potential bidders is amplified, reducing their participation and, therefore, competition in the auction, so increasing the final price. Therefore, auctions should be as recurrent, transparent and predictable as possible. The preparation and disclosure of a medium- and long-term expansion plan further assists greatly in this regard. Additionally, the high frequency and predictability of the auctions, combined with financing support from BNDES, reduced the investment risk for equipment manufacturers and construction service providers, increasing local content in the power plants without the need for specific requirements stipulated in the auction rules.

Developers and investors also need enough time to engage with the auction programme. Lead times must correspond to the longest time necessary to develop the project, secure the necessary permits and licences and deploy a new power plant.

The contract duration should also be long enough to provide investors with some cash-flow stability and predictability during the time required for loan maturity. Consequently, the contract duration should reflect the capital intensity of the technology, the principles of project financing and the discount rate involved.

The use of a portfolio of off-takers (aggregated demand of distribution companies) backed by an accounts receivable mechanism significantly mitigates payment risk and improves the developers' ability to access finance.

Auctioned contracts must be as straightforward and concise as possible in order to avoid the ambiguity that may result in future litigation, but must also provide the liability for the most common risks, limit exposure of each party involved, and clearly outline the procedures to be followed in the event of a claim.

The Brazilian experience also demonstrates that the auction programme can be used to address multiple goals with the use of complementary auctions with differences in the lead time, contract duration and contractual obligations. The auction may demand specific renewable sources or multiples sources (mix of technologies or even technology neutral), but each energy source has an individual contract, specially designed to conciliate the need of the power system and the features of different energy sources.

5.2. Auction design

The design of energy auctions must consider three main goals. First, auctions must be attractive enough to investors to generate competition and to achieve optimal prices. Second, the auction design must ensure that the preferred bidders are reliable and have the technical and financial capability to build the projects on schedule and deliver the promised energy and capacity. Third, the auction design should ensure that the right mix of products is contracted to achieve the resource adequacy of the electric system (Viscidi & Yépez, 2020).

To improve competition, secure the bidder's commitment and reduce the time needed to analyse more subjective aspects of legal and financial qualification, the Brazilian auctions are performed following three stages: the technical prequalification phase; the bidding phase; and the legal and financial qualification phase (only for the winning bids of the second stage).

Another challenge to auction design is to mitigate the winner's curse risk, understood as the failure of the investor to measure all project risks and costs (Krishna, 2002). The winner's curse cannot be entirely avoided but there are some approaches to the design of the auction and the contracts that can mitigate its effects (Correia et al., n.d.). First, the auction rules, the draft contracts, and all the information necessary for the investor to elaborate on their bidding strategy must be made available well in advance. Second, a qualification phase mitigates part of the risk, given that the bidders must prove the feasibility of the project by presenting environmental permits and financial guarantees. Third, the auction's design may help to reduce the winner's curse risk. The time and money spent to prepare the projects and participate in the auction are a sunk cost and may influence bidders' strategy. The higher the sunk cost, the greater the risk aversion of losing the auction, and the greater the aggressiveness of the bidder. Aggressive bidders think that it is more important to not lose the auction than seize a small gain of slightly increasing the bid. Consequently, the auctioneer may expect lower prices under a pay-as-bid sealed auction than under a pay-as-clear auction, but the trade-off might be a higher risk of the winner's curse in this scenario. On the other hand, a pay-as-clear process might extract less surplus from the seller and result in slightly higher prices but reduces the risk of the winner's curse.

The remaining risk must be addressed by the contracts. Contracts have multiple purposes. Primally, they are both a legal and financial tool that protects both buyer and seller from spot price volatility. Additionally, contracts provide a predictable revenue stream that can be used as collateral for long-term financing of new projects and give commercial feasibility to existing power plants in markets with significant participation of variable RE or of energy sources with low marginal cost. Finally, contracts allocate risks, define liabilities and offer guidance to act in cases of unanticipated contingencies. Therefore, to fulfil its objectives, the contract must be designed following certain principles (Correia et al., n.d.):

- Simplicity: the contract must be as simple as possible to facilitate the understanding and enforcement of its clauses;
- Coherence and comprehensiveness: the contractual clauses must be coherent with each other and with the regulatory framework and market development. The set of terms must be adequate, effective and credible and ensure capacity to respond to a changing environment;
- Clearness: the contract must clarify obligations, rights and responsibilities;
- Proportionality: the contract must provide a fair allocation of risk and liability;
- Compliance promotion: the contract needs to be self-enforceable, and the potential conflict of interest must be mitigated by positive economic incentives and the reduction of the administrative costs;
- Reality check: the policymaker or regulator accountable for the contract design must systematically assess the contract fulfilment and the sectorial outcomes to ensure that the intended objectives have been efficiently and effectively achieved. Identified flaws should be solved in the new contract;
- Funding: the contract must provide predictability and stability to the IPP cash flow.

One relevant risk for the procurement of power plants still in the project stage is the conciliation of the construction time of the power plant connection works and the deep connection works needed in the transmission grid. The combination of pre-emptive transmission corridor expansion, preliminary project elimination by connection point and a reallocation of risk to generators for transmission delays is hoped to have sufficiently decreased the likelihood of this risk being realised.

6. Conclusion

Brazil is one of the pioneers in the systematic use of energy auctions as an instrument to support public policies. The Brazilian government structured its current auction programme in 2004 with the objectives of achieving energy security, improving the efficiency of electricity contracting for captive consumers, and promoting diversification of energy supply (especially for RE).

The auction programme achieved all initial objectives and was successful in unlocking private investment in new capacity, contracting 105.2 GW from greenfield power plants, and increasing the installed capacity of 2004 (89.49 GW) by 118 per cent. More significantly, the auction programme fostered the growth of non-conventional renewable sources in Brazil at increasingly competitive prices. The competitiveness of wind and solar technologies is partly explained by the worldwide reduction in the equipment costs, due to technological advances and economies of scale, but also reflects the development of local investment capacity and the design of the auction programme.

Regarding the implementation process, the responsibility of each institution that takes part in the auction programme is clearly defined under a comprehensive regulatory framework and understood by all stakeholders. Additionally, the Brazilian programme has benefited from the performance of adequately funded institutions provided with qualified technical personnel. In fact, since 2004, the auctions have performed following the same rules and structure, with only minor adjustments in contractual clauses and in the bidding mechanism (mostly to deal with transmission connection delays).

In terms of auction design, the simplicity of winner selection criteria and the use of different stages for the qualification of projects and preferred bidders reduces the time consumed in the tender and mitigates the risk of litigation during the process. Moreover, because they are centralised mechanisms, the design of the auction can help to reduce some risks related to the contracting and implementation of infrastructure projects. In the case of the Brazilian experience, special attention was given to reducing the risk of off-taker payment, and to the risk of delay in the construction of projects.

The off-taker of the energy auctions is the pool of all distribution companies. Therefore, each preferred project signs a different contract with each distribution company in the pool and only a fraction of the energy is committed in each contract, mitigating the risk of payment. On the other hand, the amount of energy acquired by each distribution company is divided among several projects and the risk of delay is thus also mitigated. The auction also seeks to mitigate construction risk by using a prequalification process, and by requiring surety and performance bonds.

Nevertheless, auctions are not able to overcome competitive market structure problems or mitigate all risks associated with the implementation of infrastructure projects. Still, it is important that contracts establish the obligations and liabilities of generators and buyers. In the Brazilian approach, the majority of the risks related to the environmental licensing, site selection and connection with the grid are allocated to generators, assuming that even when they are not able to manage the risk, they are better able to evaluate and price the risk.

7. Final thoughts

Although there is not a one-size-fits-all auction model, other countries, especially in the African continent, where there is great potential for developing RES, may use some of Brazil's lessons to implement energy auctions.

The existence of a stable institutional framework, where the role and responsibility of each institution in the electricity sector is clear and respected, is fundamental to the design and implementation of auctions. It is up to the sectoral Ministry to define a policy for renewable sources, clarifying the expansion goals and the mechanisms to achieve them. For this, the existence of permanent technical staff, trained and with access to databases, and mathematical optimisation models are essential for the elaboration of expansion plans. Staff can act exclusively at the Ministry or, as in Brazil, be part of an institution created to prepare the system expansion studies and assist the Ministry and other stakeholders in decision-making. Equally, it is crucial to ensure that the regulatory agency has the technical and legal conditions to autonomously implement auction policies and guidelines once they are defined, without interference from other government spheres.

Investors have high costs to participate in the auctions. They must locate and rent the appropriate land, contract anemometric or solarimetric data certification, prepare the project and the studies of connection to the power grid, conduct detailed studies of environmental and socio-economic impacts and obtain the prior licence, deposit the bid bond, and so on. Therefore, it is essential to guarantee holding at least one annual auction to provide investors with security that, if they lose the auction, they will have new opportunities in the following years.

The greater the number of investors interested in the auction, the greater the auction competition and potential for success. The challenge for countries that are just initiating their auction programme is to attract a sufficient number of bidders. Thus, wide broadcasting of the auction is important. For example, Brazil discloses auctions at national and international events.

A frequent problem in encouraging local investors to participate in auctions is accessing finance. In Brazil, the National Bank for Economic and Social Development played a crucial role in financing auction winners. In African countries, the absence of a robust commercial banking system or a large national development bank can be an obstacle to local capital participation. The government's previous articulation with multilateral banks to guarantee financing of the winning projects is therefore necessary to enable the involvement of local entrepreneurs.

Like Brazil, African countries generally have enormous potential for renewable sources. However, as in Brazil, difficult economic situations prevent public companies from making the necessary investments to expand installed capacity. As shown, the auctions for guaranteeing long-term contracts have been an efficient mechanism for Brazil to attract investments from national and multinational private companies. Undoubtedly, African countries have all the conditions to follow the same path and use auctions to leverage renewable sources across the continent.

Appendix A: Analytical framework

The analytical framework used represents a widening and deepening of the work done by Eberhard and Gratwick (2011) and Eberhard et al. (2017) in their analyses of factors contributing to the success of IPPs in sub-Saharan Africa. These authors have identified a host of factors, at both country and project level, that influence the success of these projects. In particular, they have emphasised the importance of competitive procurement (Eberhard et al., 2016) without explicitly making recommendations concerning the design and implementation of such procurement programmes – largely because most of sub-Saharan Africa's IPP capacity has been procured through direct negotiations, often initiated by unsolicited proposals (Eberhard et al., 2016).

How procurement interactions between the public and private sectors need to be structured and managed is a key concern for the development of successful new renewable generation capacity in this region. Renewable energy auction design is a field of growing scholarly and practitioner interest. The work of, for example, Del Río and Linares (2014); Lucas, Ferroukhi and Hawila (2013); Kreiss et al. (2016); Del Río (2017); Lucas, Del Rio and Sokona (2017); Dobrotkova et al. (2018); Hochberg and Poudineh (2018); and Kruger and Eberhard (2018) offers a useful body of literature for developing a deeper understanding of how choices made in the design of procurement programmes can influence price, investment outcomes, and so on. Eberhard and Naude (2016) as well as Eberhard, Kolker and Leigland (2014) have also emphasised how choices made around procurement programme implementation can play a role in determining outcomes.

The analytical framework used in this case study attempts to combine lessons from the literature on IPP success factors with studies of auction design and implementation to offer a detailed and nuanced understanding of various factors that influenced the auction outcomes. Factors investigated and assessed in the study are outlined in the table below.

Factors	Details
Country level	
Stability of economic and legal context	Stability of macroeconomic policies Extent to which the legal system allows contracts to be enforced, laws to be upheld and arbitration to be fair Repayment record and investment rating Previous experience with private investment
Energy policy framework	Framework enshrined in legislation Framework clearly specifies market structure and roles and terms for private and public sector investments (generally for a single-buyer model, since wholesale competition is not yet seen in the African context) Reform-minded 'champions' to lead and implement framework with a long-term view
Regulatory transparency, consistency and fairness	Transparent and predictable licensing and tariff framework Cost-reflective tariffs Consumers protected
Coherent sectoral planning	Power-planning roles and functions clear and allocated Planners skilled, resourced and empowered Fair allocation of new-build opportunities between utilities and IPPs Built-in contingencies to avoid emergency power plants and blackouts
Competitive bidding practices	Planning linked to timely initiation of competitive tenders/auctions Competitive procurement processes are adequately resourced, fair and transparent
Programme level	

Programme design	Bidder participation is limited to serious, capable and committed companies Contracts are bankable and non-negotiable Balance between price (competition) and investment risks/outcomes is appropriate Programme is linked to and informed by planning frameworks (volume, transmission, etc.) Investment risks and costs are allocated fairly Design takes local political and socio-economic context into consideration Transaction costs (bidders and procuring entity) offset by price and investment outcomes Qualification and evaluation criteria are transparent and quantifiable Design allows for multiple scheduled procurement rounds Measures to create local capacity/market are built in through local currency PPA, shareholding requirements, etc.
Programme implementation	Both the programme and the procuring entity have appropriate and unbiased political support, as well as an appropriate institutional setting and governance structures The procuring entity is capable, resourced and respected Coordination between various government entities is effective The procurement process is clear, transparent and predictable
Project level	
Favourable equity partners	Local capital/partner contributions are encouraged Partners have experience with and an appetite for project risk A development finance institution partner (and/or host country government) is involved Firms are development minded and returns on equity are fair and reasonable
Favourable debt arrangements	Competitive financing Local capital/markets mitigate foreign-exchange risk Risk premium demanded by financiers or capped by off-taker matches country/project risk Some flexibility in terms and conditions (possible refinancing)
Creditworthy off-taker	Adequate managerial capacity Efficient operational practices Low technical losses Commercially sound metering, billing and collection Sound customer service
Secure and adequate revenue stream	Robust PPA (stipulates capacity and payment as well as dispatch, fuel metering, interconnection, insurance, *force majeure*, transfer, termination, change-of-law provisions, refinancing arrangements, dispute resolution, and so on) Security arrangements are in place where necessary (including escrow accounts, letters of credit, standby debt facilities, hedging and other derivative instruments, committed public budget and/or taxes/levies, targeted subsidies and output-based aid, hard currency contracts, indexation in contracts)
Credit enhancements and other risk management and mitigation measures	Sovereign guarantees Political risk insurance Partial risk guarantees International arbitration
Positive technical performance	Efficient technical performance high (including availability) Sponsors anticipate potential conflicts (especially related to operation and maintenance and budgeting) and mitigate them
Strategic management and relationship building	Sponsors work to create a good image in the country through political relationships, development funds, effective communications, and strategically managing their contracts, particularly in the face of exogenous shocks and other stresses

Source: Adapted from Eberhard et al. (2016)

References

ANEEL. (2016). *Nota Técnica nº 309/2016-SCG/ANEEL*.

Correia, Tiago B., Melo, E., Costa, A. M., & Silva, A. J. (2006). Trajetoria das Reformas Institucionais da Industria Eletrica Brasileira e Novas Perspectivas de Mercado. *Economia*, *7*(3), 607–627.

Correia, Tiago B., Tolmasquim, M. T., & Hallack, M. (n.d.). *Guide for designing contracts for renewable energy procured by auctions*.

Costa, C. do V. (2006). *Políticas de Promoção de Fontes Novas e Renováveis para Geração de Energia Elétrica: Lições da Experiência Européia para o Caso Brasileiro*.

del Río, P. (2017). Designing auctions for renewable electricity support. Best practices from around the world. *Energy for Sustainable Development*, *41*, 1–13. https://doi.org/10.1016/j.esd.2017.05.006

del Río, P., & Linares, P. (2014). Back to the future? Rethinking auctions for renewable electricity support. *Renewable and Sustainable Energy Reviews*, 35, 42–56.

Dobrotkova, Z., Surana, K., & Audinet, P. (2018). The price of solar energy: Comparing competitive auctions for utility-scale solar PV in developing countries. *Energy Policy*, *118*(January), 133–148. https://doi.org/10.1016/j.enpol.2018.03.036

Eberhard, A., Gratwick, K., Morella, E., & Antmann, P. (2016). Independent power projects in sub-Saharan Africa: Lessons from five key countries. In *Directions in Development – Energy and Mining*. https://doi.org/doi:10.1596/978-1-4648-0800-5

Eberhard, A., Gratwick, K., Morella, E., & Antmann, P. (2017). Independent power projects in sub-Saharan Africa: Investment trends and policy lessons. *Energy Policy*, *108*, 390–424. https://doi.org/10.1016/j.enpol.2017.05.023

Eberhard, A., & Gratwick, K. N. (2011). IPPs in sub-Saharan Africa: Determinants of success. *Energy Policy*, *39*(9), 5541–5549. https://doi.org/10.1016/j.enpol.2011.05.004

Eberhard, A., Kolker, J., & Leigland, J. (2014). South Africa's renewable energy IPP procurement program: Success factors and lessons. Public-Private Infrastructure Advisory Facility, Washington DC, USA, May, 1–56.

Eberhard, A., & Naude, R. (2016). The South African Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) – Lessons learned. *Journal of Energy in Southern Africa*, *27*(4), 1–14. https://doi.org/http://dx.doi.org/10.17159/2413-3051/2016/v27i4a1483

Hanke, A.-K., & Tiedemann, S. (2020). *How (not) to respond to low competition in renewable energy auctions Endogenous rationing in renewable energy auctions*. *817619*.

Hermes de Araújo, J. L. R., de Aragão da Costa, A. M., Correia, T., & Melo, E. (2008). Energy contracting in Brazil and electricity prices. *International Journal of Energy Sector Management*, *2*(1), 36–51. https://doi.org/10.1108/17506220810859088

Hochberg, M., & Poudineh, R. (2018). *Renewable auction design in theory and practice: Lessons from the experiences of Brazil and Mexico*. Oxford Institute for Energy Studies. https://www.oxfordenergy.org/publications/renewable-auction-design-theory-practice-lessons-experiences-brazil-mexico/

Hofmann, R. M. (2015). Gargalos do Licenciamento Ambiental Federal no Basil. Consultoria Legislativa.

Kreiss, J., Ehrhart, K.-M., & Haufe, M.-C. (2016). Appropriate design of auctions for renewable energy support: Prequalifications and penalties. *Energy Policy*. https://doi.org/10.1016/j.enpol.2016.11.007

Krishna, V. (2002). *Auction theory*. Burlington, MA: Elsevier.

Kruger, W., & Eberhard, A. (2018). Renewable energy auctions in sub-Saharan Africa: Comparing the South African, Ugandan, and Zambian programs. *Wiley Interdisciplinary Reviews: Energy and Environment*, *February*, 1–13. https://doi.org/10.1002/wene.295

Lucas, H., Del Rio, P., & Sokona, M. Y. (2017). Design and assessment of renewable electricity auctions in sub-Saharan Africa. *IDS Bulletin*, *48*(5), 79–100.

Lucas, H., Ferroukhi, R., & Hawila, D. (2013). *Renewable energy auctions in developing countries*. International Renewable Energy Agency. https://www.irena.org/documentdownloads/publications/irena_renewable_energy_auctions_in_developing_countries.pdf

Tolmasquim, M. T. (2014). *Novo Modelo do Setor Elétrico Brasileiro* (2nd ed.). SYNERGIA EDITORA.

Viscidi, L., & Yépez, A. (2020). *Clean energy auctions in Latin America*. Inter-American Development Bank. https://www.thedialogue.org/wp-content/uploads/2020/01/Clean_Energy_Auctions_in_Latin_America.pdf

World Bank Group: Energy and Extractives. (2012). International experience with private sector participation in power grids: Peru case study. In *Energy Sector Management Assistance Program*.