Report on the Brazilian Power System

Version 1.0

COUNTRY PROFILE

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IMPRINT

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Preface

Dear readers,

The energy transition is transforming our economies with increasing speed: it will have profound impacts on communities, industries, trade and geopolitical relations. Concerns about climate change and energy security have been at the root of new technological developments. However, renewable energy sources with decreasing costs are now disrupting traditional fossil-based energy systems even without subsidies. This shift is supported by innovative solutions for digital control and energy storage that allow us to integrate increasingly variable and decentralised energy generation resources. In addition, emerging technologies, such as electromobility or the production of electrofuels, will allow renewable energy to substitute fossil fuels even in transport and industry.

The social and economic opportunities that arise from this potential for electrification at low financial and environmental cost are attracting the attention of proactive policymakers around the world. Energy transition investment is an economic growth opportunity. Capital markets are shifting their assets towards green investment opportunities. Nonetheless, many countries will need decades to substitute existing fossil-fuel based power generation capacities, and establish the predominantly renewable electricity systems that are needed for the successful decarbonisation through electrification of other sectors.

Brazil, a large and diversified economy, is ahead of the curve. Brazil is in a unique position with its predominantly renewable and diversified power system that offers it the chance to lead the development of the energy system of the future. For Brazil this represents a much-needed opportunity to foster investments that promote socio-economic development and support the modernization of industry to boost productivity and economic growth. Brazil's experience can also provide important lessons for other countries. This prospect is increasingly recognised by energy specialists in the private sector, civil society and government. However, the successful transition to the energy system of the future in Brazil will require a broad and inclusive societal dialogue. Only if all stakeholder interests are recognised, will it be possible to minimize negative impacts and maximize the positive socio-economic benefits of this transition.

With this in mind, Agora Energiewende and Instituto Clima e Sociedade (iCS) have teamed up to create E+ Energy Dialogues Institute as an independent energy think tank that can convene Brazil's diverse stakeholders to discuss the challenges and opportunities of such a vision. The purpose of this initiative is to ensure an inclusive and fact-based dialogue that can engage the energy sector as a vector for Brazil's robust and sustainable economic growth. In this document, we are presenting a Brazil Country Report as an introductory reading for international and national actors who wish to prepare for this dialogue.

We hope that you enjoy this reading and we are looking forward to discussions with you about the opportunities of a successful Brazilian energy transition.

Philipp Hauser
Senior Associate Agora Energiewende

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Executive Coordinator E+ Energy Dialogues Institute

Content

Acronyms

ACL	Free Electricity Market (Ambiente de Contratação Livre)
ACR	Regulated Electricity Market (Ambiente de Contratação Regulada)
ANEEL	National Agency for Electrical Energy (Agência Nacional de Energia Elétrica)
ANP	National Agency for Oil, Natural Gas, and Biofuels (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis)
BNDES	Brazilian Development Bank (Banco Nacional de Desenvolvimento Econômico e Social)
CCC	Fuel Consumption Account (Conta de Consumo de Combustíveis)
CCEE	Chamber of Electricity Commercialisation (Câmara de Comercialização de Energia Elétrica)
CDE	Energetic Development Account (Conta de Desenvolvimento Energético)
CFURH	Financial Compensation for the Use of Water Resources (Compensação Financeira pela Utilização de Recursos Hídricos)
CMSE	Monitoring Committee for the Electricity Sector (Comitê de Monitoramento do Setor Elétrico)
CNPE	National Council for Energy Policy (Conselho Nacional de Política Energética)
COFINS	Contribution to the Financing of Social Security (Contribuição para o Financiamento da Seguridade Social)
CONFAZ	National Council of Treasury Policy (Conselho Nacional de Política Fazendária)
COSIP/CIP	Contribution for Public Lighting Services (Contribuição para o Custeio da Iluminação Pública)
CP	Public Consultation (Consulta Pública)
CVA	Compensation Account for Component A (Conta de Compensação de Variação de Valores de Itens da Parcela "A")
DEC	Equivalent Duration of Interruption per Consumer Unit (Duração Equivalente de Interrupção por Unidade Consumidora)
EER	Reserve Energy Charge (Encargo de Energia de Reserva)
EPE	Energy Research Office (Empresa de Pesquisa Energética)
ESS	System Service Charge (Encargo de Serviços do Sistema)
FEC	Equivalent Frequency of Interruption per Consumer Unit (Frequência Equivalente de Interrupção por Unidade Consumidora)
GSF	Generation Scaling Factor
HHI	Herfindahl-Hirschman Index
ICMS	Tax on Circulation of Merchandise and Services (Imposto sobre Circulação de Mercadorias e Serviços)
IGP-M	General Price Index of the Market (Índice Geral de Preços do Mercado)
iNDC	Intended Nationally Determined Contribution
IPCA	Broad Consumer Prices Index (Índice de Preços ao Consumidor Amplo)
LEE	Auction for Existing Energy (Leilão de Energia Existente)
LEN	Auction for New Energy (Leilão de Energia Nova)

LER	Reserve Energy Auction (Leilão de Energia de Reserva)
LFA	Renewable Energy Auction (Leilão de Fontes Alternativas)
MCP	Short-Term Market (Mercado de Curto Prazo)
MCSD	Compensation Mechanism of Credits and Debits (Mecanismo de Compensação de Sobras e Déficits)
MEPS	Minimum Energy Performance Standard
MME	Ministry for Mines and Energy (Ministério de Minas e Energia)
MOC	Marginal Operation Cost (Custo Marginal de Operação)
MP	Provisory Legal Measure (Medida Provisória)
MRE	Energy Reallocation Mechanism (Mecanismo de Realocação de Energia)
NDC	Nationally Determined Contribution
ONS	National System Operator (Operador Nacional do Sistema Elétrico)
PDE	10-year Energy Plan (Plano Decenal de Expansão de Energia)
P&D/EE	Research and Development and Energy Efficiency (Pesquisa e Desenvolvimento e Eficiência Energética)
PIS	Social Integration Programme (Programa de Integração Social)
PL	Law Project (Projeto de Lei)
PLD	Differences Settlement Price (Preço de Liquidação de Diferenças)
PNE	Long-term National Energy Plan (Plano Nacional de Energia)
PNEF	National Energy Efficiency Plan (Plano Nacional de Eficiência Energética)
PPA	Power Purchase Agreement
PV	Solar Photovoltaics
RAP	Allowed Annual Revenue for Transmission Companies (Receita Anual Permitida)
REIDI	Special Incentive for the Development of Infrastructure (Regime Especial de Incentivos para o Desenvolvimento da Infraestrutura)
RES	Renewable Energy Sources
RGR	Global Reversal Fund (Reserva Global de Reversão)
RN	Normative Resolution (Resolução Normativa)
SAIDI	System Average Interruption Duration Index
SIN	National Interconnected System (Sistema Interligado Nacional)
TFSEE	Electric Energy Service Inspection Fee (Taxa de Fiscalização dos Serviços de Energia Elétrica)
TUSD	Use of Distribution System Tariff (Tarifa de Uso do Sistema de Distribuição)
TUST	Use of Transmission System Tariff (Tarifa de Uso do Sistema de Transmissão)

1 Overview

This report explores the structure of the Brazilian power sector. It considers the country's power mix, production and consumption levels, ownership and market structures, cross-border trade, and energy policies, while also giving an overview of recent sectoral developments.

Main Indicators

Total population: 207.66 million (2017)
GDP: R$ 6.6 trillion (2017)
Average electricity consumption per household: 1,895 kWh/year (2017)
Gross electricity consumption: 526.2 TWh (2017)
Installed capacity: 157 GW (2017)
Peak demand: 85.7 GW (2017)

IBGE (Agência IBGE Website); EPE (2018a), (2018b), ANEEL (2017a), ONS (2018)

The Brazilian power system is by far the largest in Latin America and currently ranks 9th on the list of the world's largest electricity markets. At the end of 2017, Brazil's installed generation capacity stood at 157 GW. More than 80 per cent of the country's electricity is derived from renewable sources, and particularly from large hydropower plants. The power system is backed up by fossil fuel thermal power plants, which have made a significant contribution to overall power generation during the country's recent droughts. Biomass power plants (most of which are fuelled by sugarcane bagasse) and wind power facilities are making an ever-greater contribution to electricity generation, while centralised solar PV generation accounted for less than 0.6 per cent of installed capacity in 2017.

The Brazilian power sector was a state monopoly until the 1990s. The first attempt to liberalise and restructure the sector was concluded in 1998. The new model failed to promote sufficient investment, which resulted in a severe energy crisis in 2000 and 2001. The government thus undertook a second power sector reform in 2004. Despite the privatisation efforts since the 1990s, market participation by private sector companies has varied considerably over the last decades. In the wake of the 2017 CP 33 public consultation, a third broad sector reform is currently on the political agenda (see section 11).

Electricity in Brazil is commercialised in two separate markets: the regulated electricity market (ACR), in which generators and distributors close bilateral contracts via government auctions, and the free electricity market (ACL), in which eligible consumers buy energy directly from generators or traders. Today, only larger consumers are allowed to participate in the free market. At the end of 2017, there were 5,158 consumers on the ACL, most of them industrial and large commercial consumers. On the ACR, there were 82.3 million captive consumers, most of which were households, businesses, small industrial users, and public sector consumers. In 2017, the ACR accounted for 67.6 per cent of overall electricity consumption and the ACL for 77 per cent of industrial energy consumption. The current reform proposal for the sector, which is still being debated, provides for the expansion of the ACL to gradually include all consumers by 2028.

Brazil's electricity consumption has increased by an average of 4.4 per cent per year over the last two decades and is expected to more than triple by 2050. As part of its commitments under the Paris Agreement, the country has announced its intention to increase the share of renewables other than hydropower to at least 23 per cent of the power mix by 2030. Where energy efficiency is concerned, it aims to reduce consumption by 10 per cent (or 106 TWh) against the projected business as usual consumption by 2030.[1]

1 Brazil's NDCs include an economy-wide emissions reduction target, with indicative measures for individual sectors such as the energy sector. These sectoral targets do not represent formal commitments.

2 Industry Structure, Ownership, and Regulation

2.1 Industry Structure

Historically, Brazil's power sector was vertically integrated and dominated by large public companies owned by either the federal Eletrobras group or by state governments. This model was responsible for the financing and implementation of important investments, including the large hydropower plants Itaipu (14 GW) and Tucurui (8.4 GW), as well as the country's extensive transmission and distribution grid. When the Brazilian debt crisis hit in the late 1980s, the model became unsustainable and the mid-1990s saw the introduction of sweeping reforms, which included the liberalisation of electricity generation and commercialisation and the opening of the sector to private and foreign investment. The liberalised market model failed to ensure sufficient investments and, in 2001–2002, a severe energy crisis disrupted the sectoral transformation[2]. A second sectoral reform, which resulted in the 2004 New Industry Law, aimed to address the misleading market signals on capacity expansion that had contributed to the earlier crisis. The New Industry Law ensured the full unbundling of the sector, i.e. the separation of generation, transmission, and distribution. Due to strong social and political opposition, the process of privatisation envisaged in the 1990s was suspended, but the New Industry Law provided incentives for private investment in generation, transmission and distribution and resulted in the strong growth of so-called Independent Power Producers (PIE).

2 The 2001 energy crisis was a consequence of increased electricity demand and low investment in generation and transmission capacities, combined with a long period of drought that severely reduced water reservoir levels. In order to avoid blackouts, the government implemented a rationing scheme to cut 20% of national electricity consumption. As a result, residential consumption dropped sharply from 83.6 TWh in 2000 to 73.7 TWh in 2001 and continued to decrease gradually in 2002. Electricity consumption only reached pre-crisis levels again in 2006.

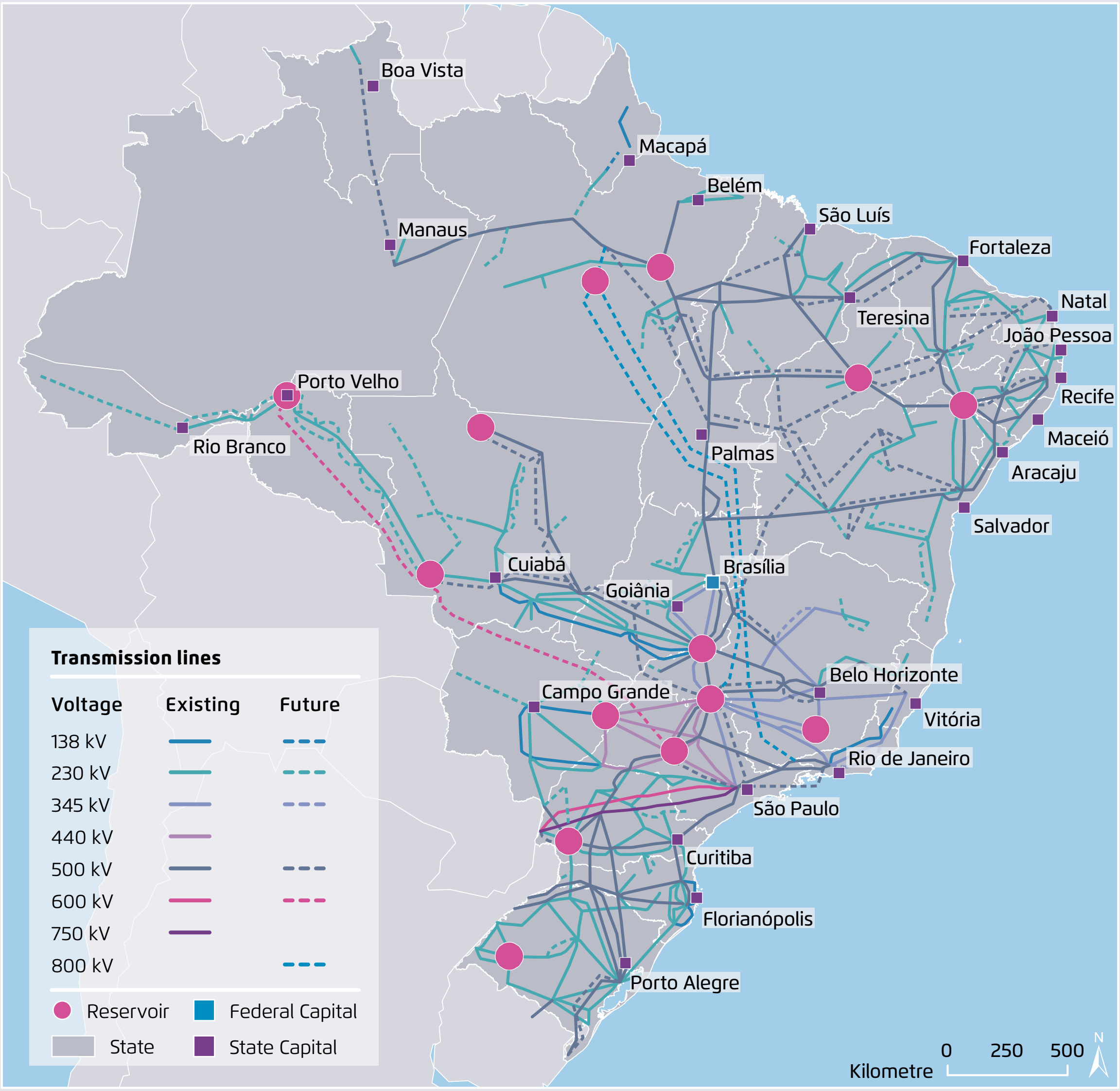
According to figures from Brazil's National Agency for Electrical Energy, ANEEL, 4,908 companies were active in electricity generation in December 2017, and the country had an overall installed capacity of 157 GW. Generation is dominated by large hydropower plants, but there are also over 2400 small and medium-sized fossil fuel based thermal power plants, many of them located in isolated power systems of the Amazon region, which account for 17.2 per cent of installed capacity. Biomass and wind energy make up a growing share of total generation, while the overall installed capacity of solar PV totalled less than 1 GW at the end of 2017.[3]

Electricity transmission and distribution are fully regulated and are assigned to public and private sector companies via concessions. Brazil has a large transmission grid, the National Interconnected System (SIN), which consists of four subsystems: South (S), Southeast/Centre-West (SE/CO), Northeast (NE) and North (N). The diversity and the complementarity of the hydrological conditions in the four subsystems allows for synergies in the SIN.

The SIN is operated by the independent National System Operator (ONS) and regulated by the ANEEL. At the end of 2016, the SIN consisted of 134,765 km of transmission lines and satisfied 99 per cent of overall electricity demand. The remaining 246 isolated power systems are mostly located in the states of Acre, Amapá, Amazonas, Pará, Rondônia, and Roraima, in the North of the country. The only state capital with an isolated grid is Boa Vista, in the state of Roraima. Most of the isolated power systems use diesel as their main source of electricity generation. The MME defines the expansion of the SIN based on studies carried out by ONS and EPE. Auctions assign the concessions for the implementation and operation of transmission lines and substations.

3 ANEEL (2017a)

Map of the SIN and its main interconnections — Figure 2.1



Authors' own illustration based on ONS (2017) and CCEE (2016)

Figure 2.1 shows a map of the SIN and its main interconnections.

Electricity distribution is managed by 63 concessionaires, most of which are large private sector companies. The 10 largest distribution companies have a combined market share of 58 per cent. In addition, there are several licence holders and authorised institutions (consisting mainly of rural electricity cooperatives) that provide distribution services in remote areas.

Electricity is commercialised in two different markets: the Free Electricity Market (ACL) and the Regulated Electricity Market (ACR) (see section 5.1.1).

Major players in the electricity sector:
Eletrobras, which once held a vertically integrated state monopoly on electricity, remains the largest company on the electricity market. Today, it is a mixed capital company controlled by the federal government. Together with its subsidiaries, it owns 31 per cent of Brazil's installed generation capacity, including a 50 per cent stake in the Itaipu binational power plant and 48 per cent of the country's transmission lines (around 70,201 km). The privatization of Eletrobras and its subsidiaries is currently under discussion.

ENGIE Brasil Energia S.A., which is 68.7 per cent owned by the French company ENGIE, is one of the largest private electricity generators in Brazil. ENGIE Brasil Energia's overall installed capacity totals 8.7 GW, 83 per cent of which stems from hydropower plants, with a further 12 per cent deriving from thermal power plants and 5 per cent from non-conventional renewable energy sources. The company sells around half of its electricity on the ACR and half on the ACL.

The main players in the electricity sector

Figure 2.2

GENERATION (Installed Capacities) - 2017 [a]

Leading companies	Company type	Market share
CHESF*	Mixed capital	7.2%
Furnas*	Mixed capital	6.4%
Eletronorte*	Mixed capital	6.2%
ENGIE Brasil Energia	Private	4.9%
Itaipu Binacional**	Mixed capital	4.7%
Petrobras	Mixed capital	4.2%
Rio Paraná Energia	Private	3.4%
Copel Geracao e Transmissao	Mixed capital	3.3%
Norte Energia	Private	3.1%
Energia Sustentável do Brasil	Private	2.5%
Others	–	54.1%
TOTAL		**100%**

DISTRIBUTION (Consumption) - 2017 [a]

Leading companies	Company type	Market share
Eletropaulo	Private	10.5%
Cemig Distribuição	Mixed capital	8.0%
Copel Distribuição	Mixed capital	6.5%
CPFL / State Grid	Private	6.3%
Light	Private	6.3%
COELBA	Private	5.2%
Celesc Distribuição	Mixed capital	4.5%
CELG - ENEL	Private	3.5%
Elektro	Private	3.5%
CELPE	Private	3.4%
Others	–	42.3%
TOTAL		

TRANSMISSION (Lines length) [b]

Leading companies	Company type	km (2016)	Market share
Eletrobras	Mixed capital	70,148	52%
CTEEP	Private	18,633	14%
TAESA	Private	9,978	7%
Cemig	Mixed capital	9,500	6%
State Grid	China state owned	7,580	5%
Alupar (Alusa Participações)	Private	4,750	4%
Abengoa	Private	3,320	2%
Others	–	11,038	8%
TOTAL		**134,947**	**100%**

COMMERCIALISATION - 2016 [b]

Leading companies	Company type	Market share
BTG Pactual Comercializadora	Private	9.0%
Engie Brasil Comercializadora	Private	8.8%
Votener (Votorantim)	Private	7.8%
EDB Comercializadora	Private	5.9%
CPFL / State Grid	Private	5.5%
NC Energia (Neoenergia)	Private	3.7%
Comerc	Private	3.4%
Others	–	55.9%
TOTAL		**100%**

* Eletrobras subsidiary ** 50% Eletrobras / 50% ANDE - Paraguay

(a) ANEEL (2017a); (b) Bank of America (2017)

CPFL is owned by the Chinese group State Grid and is the largest integrated private sector company. It is active in electricity generation and distribution in São Paulo and Rio Grande do Sul in particular.

CTEEP is Brazil's largest private electricity transmission company, with a market share of 14 per cent.

Figure 2.2 provides an overview of the main companies operating in the electricity sector's four market segments and gives their respective market shares.

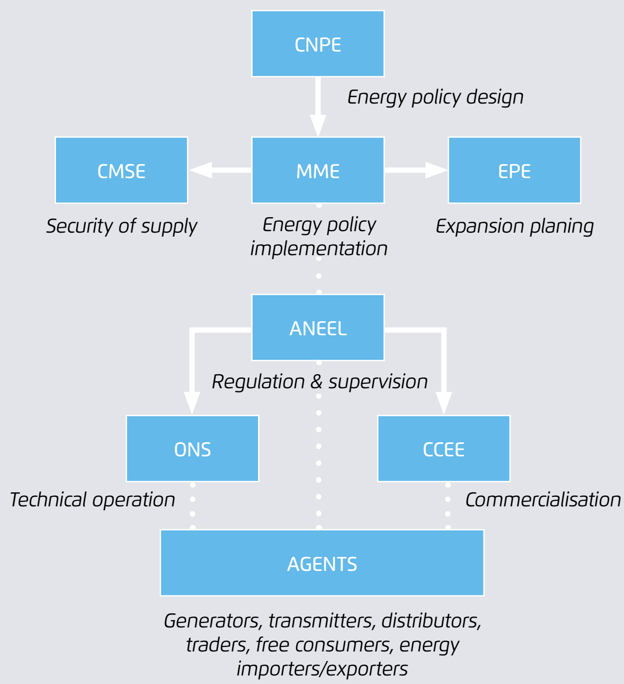
2.2 Policy Design and Regulation

The Brazilian Federal Constitution assigns responsibility for regulating the energy sector to the federal government. The current regulatory framework is specified by the Constitution of 1988, along with several laws concerning concessions, licences, and public services. Most of the government institutions in the electricity sector were created in the 1990s and in 2004. In 2004, the government carried out sweeping reforms to the electricity sector on the back of the New Industry Law. This resulted in the sector being restructured and divided into the regulated electricity market (ACR) and the free electricity market (ACL, see section 5.1.1).

Figure 2.3 illustrates the relationships between the key institutional bodies in the Brazilian electricity sector.

The National Council for Energy Policy (CNPE) is a multi-ministerial board chaired by the Mines and Energy Minister. The CNPE serves as an advisory

The key institutional bodies in the Brazilian electricity sector — Figure 2.3



Authors' own illustration

board to the Presidency of the Republic for the purposes of energy policy design, focussing particularly on security of supply and the development of the country's energy resources. The council is comprised of fourteen members, most of whom are ministers. One seat is reserved for a civil society representative and another for an academic energy specialist.

The Ministry for Mines and Energy (MME) is the main government institution responsible for energy sector legislation, and for the regulation, supervision, and control of policies designed to foster the development of the sector. The New Industry Law of 2004 assigned some of the responsibilities of the regulator ANEEL , back to the MME.

The Energy Research Office (EPE) is a public entity that carries out technical studies and provides input on the government's energy planning on behalf of the MME. The EPE also provides technical support for the auctioning of generation capacities.

The Monitoring Committee for the Electricity Sector (CMSE) oversees the continuity and reliability of electricity supply and provides the CNPE with proposals for preventive and corrective measures. The CMSE is coordinated by the Energy Minister and includes four MME representatives alongside the CEOs of ANEEL, ANP, CCEE, EPE, and ONS.

The National Agency for Electrical Energy (ANEEL) regulates and supervises the production, transmission, distribution, and commercialisation of electrical energy. The ANEEL sets the electricity transport and consumption tariffs and ensures the financial and economic feasibility of transmission and distribution concessions. The ANEEL also settles administrative disputes between companies operating in the power sector. It is structured as an autonomous federal regulatory agency and is linked to the MME. Its board of directors is comprised of one general director and four additional directors who are appointed by the President of the Republic but also have to be approved by the Federal Senate. The directors' mandates last four years, with their respective tenures beginning at different times in order to limit political influence in the agency [4].

The Chamber of Electricity Commercialisation (CCEE) is a non-profit, private legal entity that is regulated and supervised by the ANEEL and oversees the commercialisation of electricity for the SIN. The CCEE is responsible for executing energy auctions and maintains records of all the energy contracts. Moreover, the entity is responsible for the accounting of energy generation and consumption, as well as the settlement of payments or the sanctioning of defaults. The CCEE also calculates the differences settlement price (PLD) and settles financial differences between contracted and supplied amounts.

The independent National System Operator (ONS) is a non-profit, private legal entity, regulated and supervised by the ANEEL, which functions as the Brazilian Transmission System Operator (TSO). A key responsibility of the ONS is to determine and organize the plant dispatch according to their merit order and under consideration of grid constraints, resource availability and climate projections. The ONS supports energy planning by proposing network expansions and measures to strengthen the existing system.

The National Agency for Oil, Natural Gas and Biofuels (ANP) is not strictly part of the electricity sector but does affect energy policymaking, since it participates in the CMSE. The ANP is linked to the MME and is responsible for regulating and supervising oil, natural gas, and biofuel industries in Brazil.

4 By law, the tenures of regulatory agency directors should not coincide. In practice, however, gaps between the end and beginning of mandates means that some tenures do end up coinciding. This issue has been addressed by a new legislative proposal for regulatory agencies (PL 6621/2016), which is currently being debated in Congress.

3 Energy Production and Consumption

3.1 Installed Capacity

At the end of 2017, Brazil's overall installed capacity[5] stood at 157.1 GW. Renewable energy sources accounted for 128 GW, or 81.5 per cent, of this capacity. The power mix is dominated by large hydropower plants, which accounted for 60 per cent of installed capacity. Biomass power plants, which are mainly fuelled by sugarcane bagasse, accounted for a sizeable 9.2 per cent of overall capacity. Wind power accounted for 7.8 per cent of installed capacity at the end of 2017, while centralized solar photovoltaic facilities represented only 0.9 GW of installed capacity, or 0.6 per cent of overall generation capacity.

5 Excluding distributed electricity generation from the Brazilian Net-Metering scheme (see section 8.2)

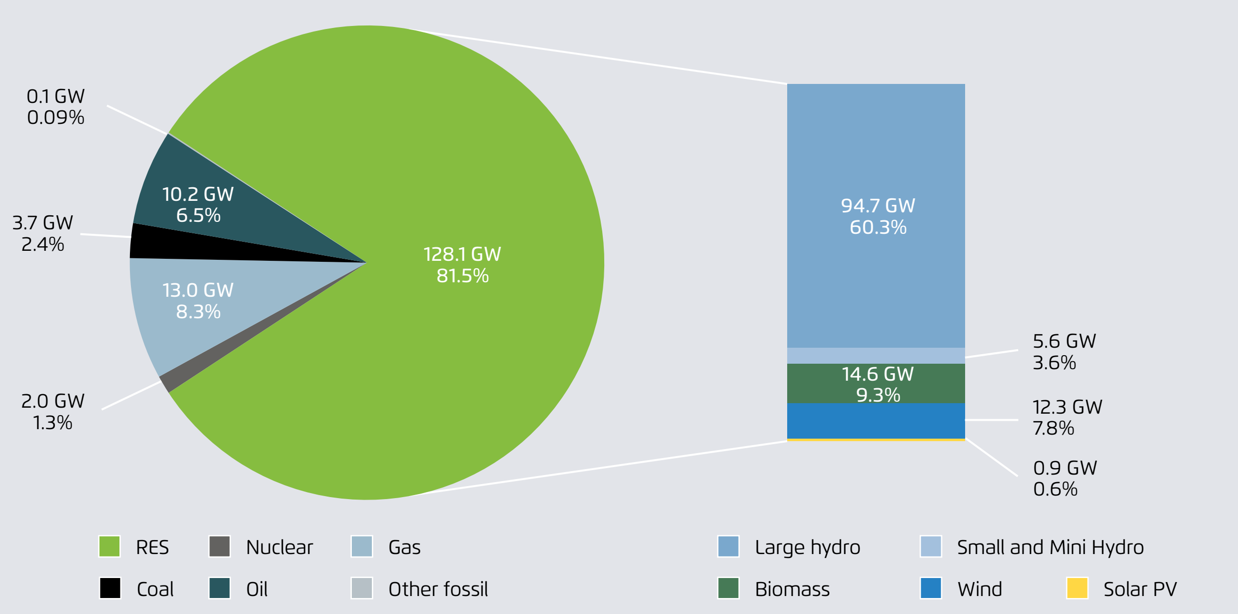
Fossil fuel generation capacities, dominated by oil and gas power stations, accounted for 18.5 per cent of total installed capacity in December 2017. In addition, Brazil has two nuclear power plants, Angra I and Angra II, which have a combined capacity of 2 GW. The plants began operations in 1984 and 2001, respectively.

Figure 3.1 shows Brazil's installed generation capacity by source, as of December 2017.

3.2 Production

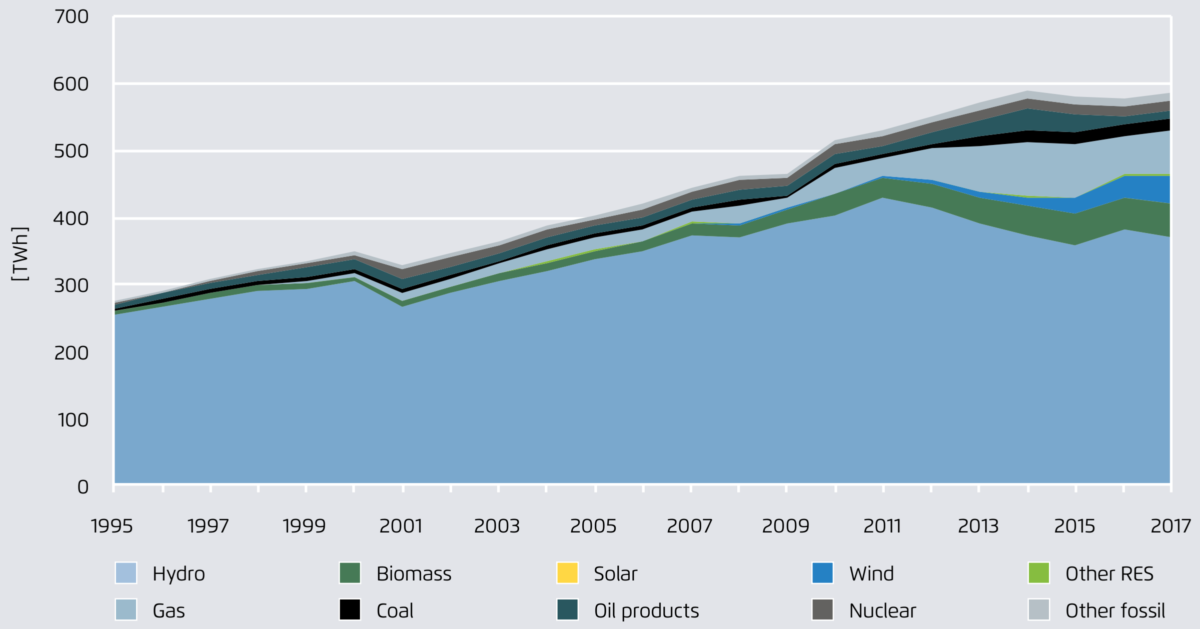
In 2017, Brazilian electricity production totalled 588 TWh. Renewable sources accounted for nearly 79 per cent of all generation, and hydropower for 63.1 per cent alone. The overall share of production accounted for by renewables remained the same as

Installed generation capacity by source (2017) — Figure 3.1



ANEEL (2017a)

Brazilian electricity generation by source (1995 – 2017) Figure 3.2



EPE (2018)

in 2016. In 2017, a reduction in hydroelectric power generation due to unfavourable hydrological conditions was offset by an increase in wind power generation. Natural gas and biomass accounted, respectively, for 11.2 per cent and 8.4 per cent of overall electricity generation.[6]

3.3 Consumption

In 2017, Brazilian electricity consumption was 0.93 per cent higher than in 2016, at 526.2 TWh. Despite certain exceptional periods, such as the energy crisis of 2001-2002 and the current economic crisis, consumption has grown at an average annual growth rate of 4.4 per cent over the past two decades. According to the EPE's latest forecasts, which are based on a projected annual growth rate of 3.6 per cent, electricity consumption will reach 654 TWh in 2026.[7] By 2050, demand for electricity is expected to more than triple to 1,605 TWh.[8]

At 2,514 kWh in 2016, Brazilian per capita consumption remains relatively low in comparison with industrialised countries. Electricity was brought to many poor rural areas through the "Light for All" (*Luz para Todos*) government initiative, with 97.8 per cent of households having electricity in 2010[9]. Despite this high level of electrification, a large number of low-income households still consume extremely

6 The reduction in hydroelectric power generation since 2011 was compensated by increasing shares of wind and biomass power generation, but the growing electricity demand required an increasing dispatch of expensive peak generation units that run on fossil fuels.

7 EPE (2017a)

8 EPE (2016)

9 EPE estimates that the universalisation program Light for All served a population of almost 3 million people from 2011 to 2017 (EPE 2018a).

small amounts of electricity, though consumption levels as a whole are expected to match those of industrialised countries by 2050.

3.4 Peak Demand

Peak demand in Brazil generally occurs in the middle of the afternoon during the summer months (from December to March), when high temperatures lead consumers to turn on their air-conditioning units. In 2017, demand peaked at 85.7 GW at 2.30 pm on February 20th. Demand was lowest at around 6 am on the 1st May international holiday, at 41.2 GW

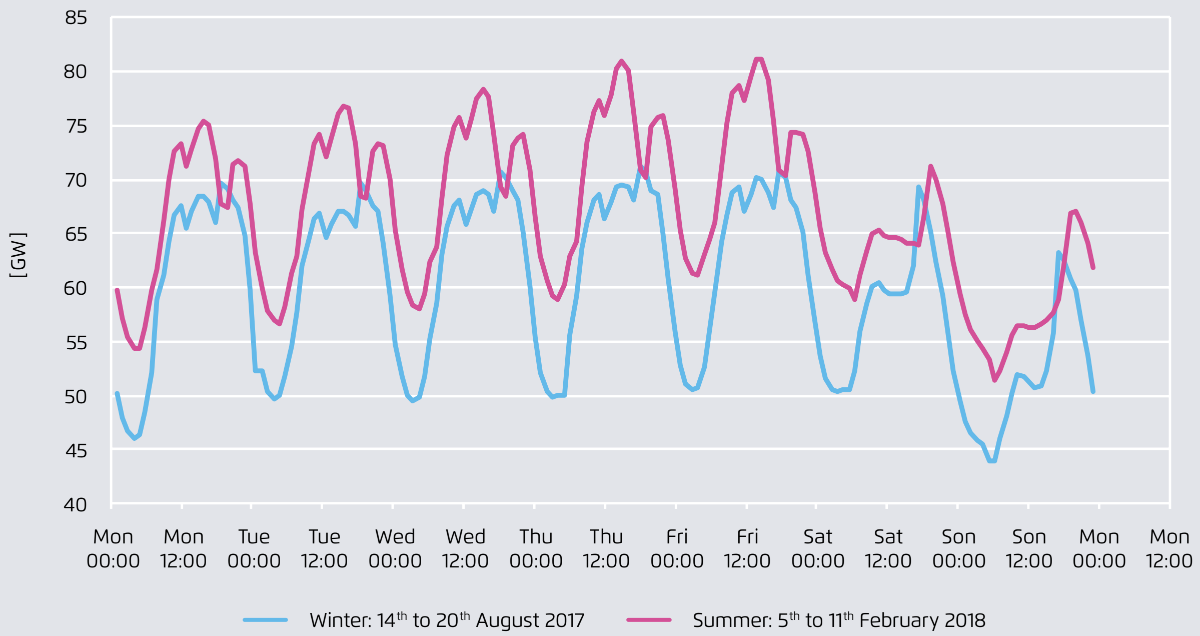
Studies suggest that real demand between 5 pm and 9 pm is in fact much higher than the observed load curve of the SIN. Due to the high peak load tariffs for large consumers between 5 pm and 9 pm, these consumers resort to distributed electricity generation using diesel and gas generators rather than drawing electricity from the grid. The EPE has estimated that these distributed generation units lower the SIN's load curve by 7-9 GW (around 10%) during peak load hours. As a result, peak summer loads in the SIN have shifted from the evening to the afternoon since 2008.[10]

Figure 3.3 shows typical weekly summertime and wintertime load curves in the SIN in 2017/2018. The slight shift in the evening peak values is due to the variable peak load hours in some of the concession areas. These run from 6-9 pm (and from 7-10 pm during daylight saving hours).[11]

10 EPE (2015)

11 Most Brazilian electricity consumers are subject to daylight saving time, which is implemented by 10 of the 27 federal states from mid-October to mid-February.

Typical weekly load curve in the SIN — Figure 3.3



ONS (2018)

3.5 Planned Conventional Power Plants

The ANEEL is responsible for authorizing the development of power plants both in the SIN as well as in the remaining isolated power systems. The ANEEL keeps a complete register of all power plants under development, though not all of these plants are completed or put in operation.[12]

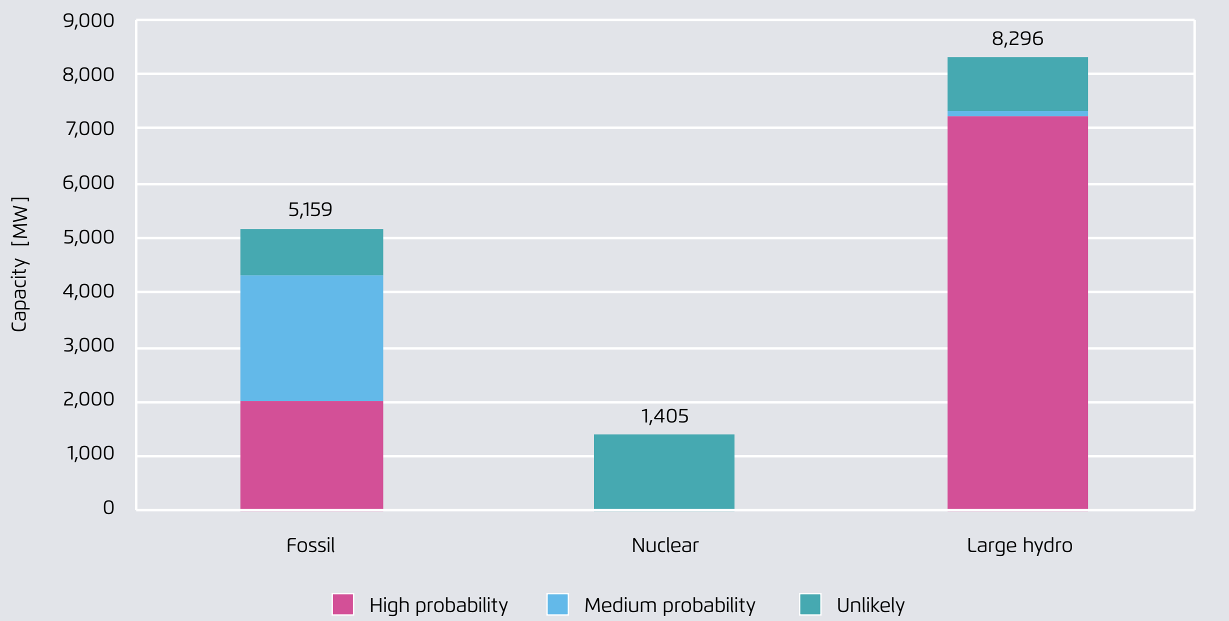
As of May 2018, the ANEEL had reported a total of 606 projects in the development pipeline, representing 24.16 GW of total additional capacity. 61.5 per cent of these power plants (accounting for 14.85 GW of power) are being developed with conventional energy sources, including fossil-fuel thermal power plants, nuclear power plants and large hydropower plants, which are implemented via concessions. According to the ANEEL, 23% of the power plants that have already been authorised to connect to the grid are considered "unlikely to be implemented" due to environmental, regulatory, technical, or financial constraints (see Figure 3.4).

Figure 3.4 shows the planned new conventional and large hydro power plants up to 2023, according to their likelihood of being commissioned over the next five years.

The nuclear generation capacity shown in the graph refers to the planned third thermonuclear plant at the Almirante Álvaro Alberto facility (formerly Angra III, now named Unit III). Discussions on the construction of this plant have been underway since 1975, and building began in 1984 but was later abandoned. Attempts were made to continue construction in 2010, but all works are currently on hold.

12 The ANEEL developed a method for monitoring and evaluating the probability of a project's becoming operational and takes different phases of project development into account.

Planned conventional capacity by energy source up to 2023 — Figure 3.4

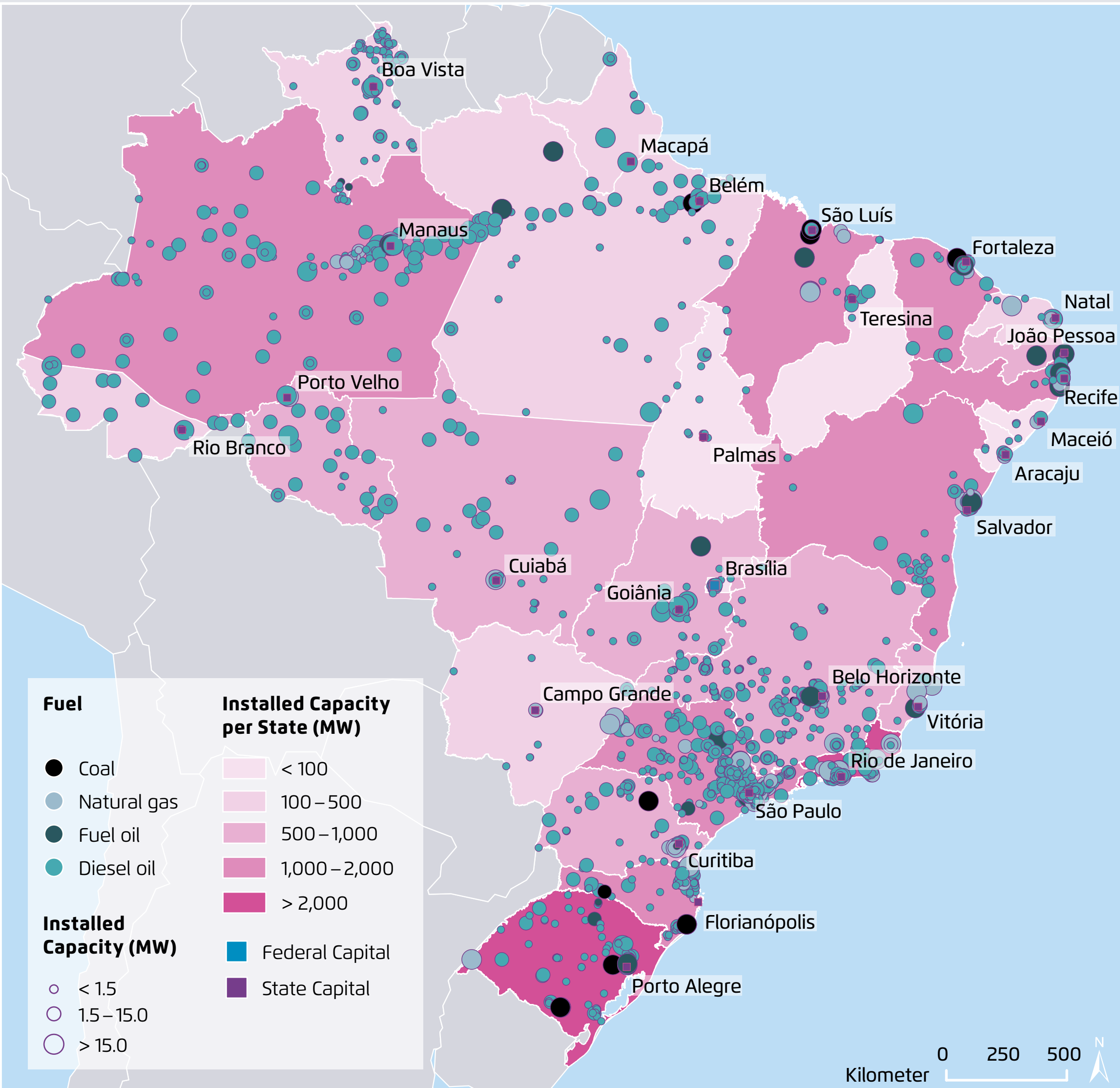


ANEEL (2018b)

The results of the most recent round of energy auctions are not included in the above figures. In the scope of these auctions (New Energy Auctions 25, 26, and 27), two natural gas thermal power plants with a total capacity of 2,138.9 MW were contracted at 213.46 R$/MWh.

It is important to mention, that fuel oil thermal power plants still play an important role for powering the isolated systems in the North of the country. Figure 3.5 shows the locations of all operational fossil fuel thermal power plants as of July 2018.

Fossil fuel thermal power plants in operation in July 2018 — Figure 3.5

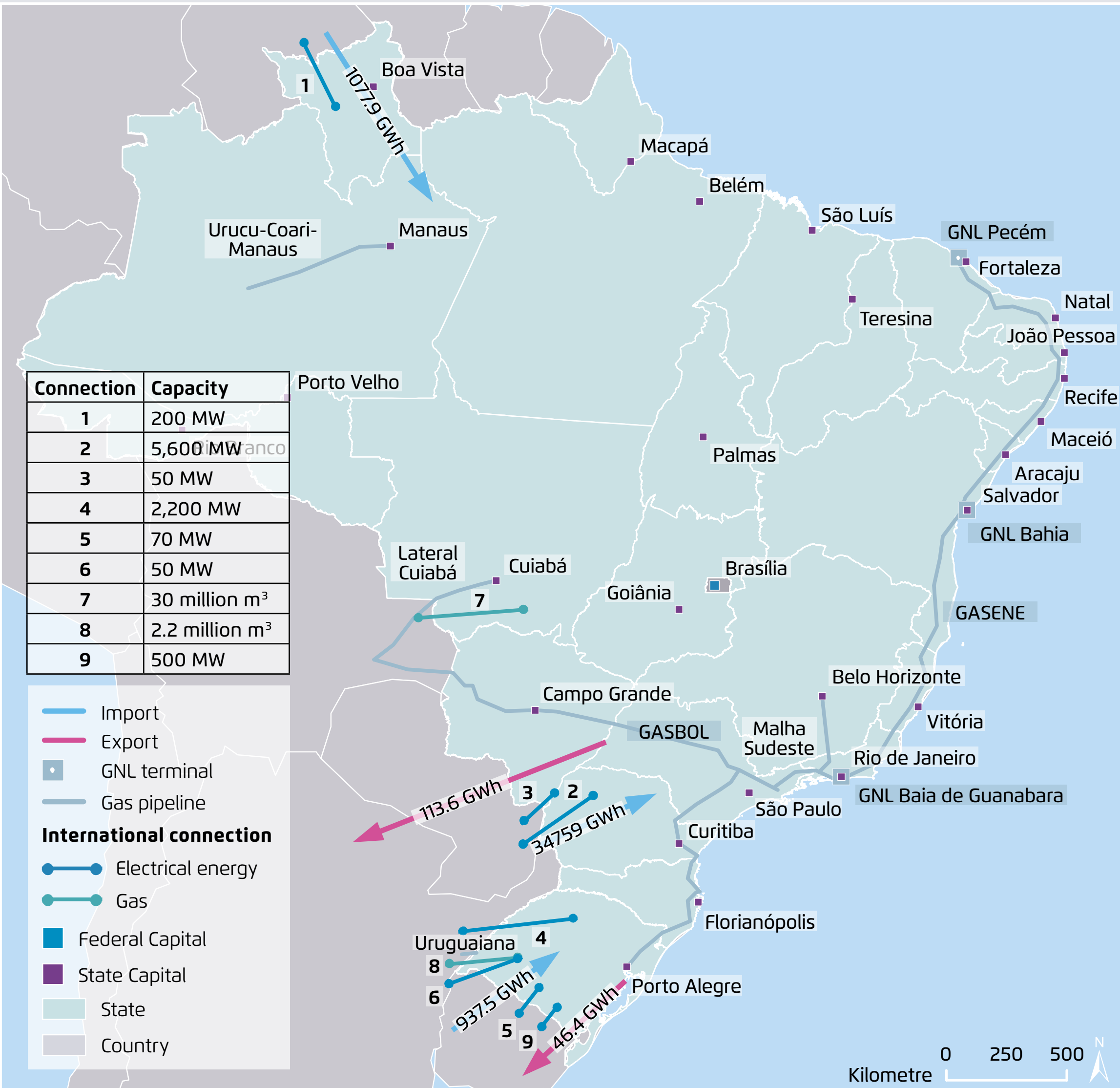


Authors' own illustration, based on ANEEL (2018c)

4 Imports and Exports

Brazil's SIN is interconnected with Argentina, Uruguay and Paraguay. The interconnection with Argentina has a total capacity of 2,250 MW; the interconnection with Uruguay 570 MW. Due to the differences in frequency between the respective power systems (Brazil's operates at 60 Hz and Argentina's, Uruguay's, and Paraguay's at 50 Hz), converters are installed at the borders to allow the interchanges.

Interconnections between Brazil and its neighbours — Figure 4.1



Authors' own illustration based on information from ONS (2018)

The energy integration with Paraguay runs via the 14 GW Itaipu hydroelectric power plant – a binational enterprise located on the border between the two countries. The excess energy from the Paraguayan side is sold to Brazil as per the initial contract, which ends in 2023 and will have to be renegotiated before its expiry.

Due to the commercial arrangement for importing significant amounts of Paraguay's share of the binational generation from Itaipu, Brazil is a structural net importer of electrical energy. In 2017, net electricity imports totalled 36,355 GWh. Net imports were equivalent to 6.9 per cent of overall electricity consumption.[13]

International electricity exchange takes place in a variety of ways.

"Opportunity exchange" of electricity, as well as exchange for emergencies or the purpose of testing, does not involve financial transactions. All of the electricity imported must later be returned to the exporting country in full.

Electricity from thermal power stations and excess hydropower that cannot be absorbed by the SIN, meanwhile, may be commercially imported and exported via bilateral contracts in the ACL.

Additionally, there is the possibility for commercial imports from Argentina. This option also forms part of the ONS optimization model of the SIN.

Since 2008, Brazil has also been able to export excess electricity from the SIN to Argentina and Uruguay, in return for either an equal quantity of electricity or financial reimbursement at the current price for thermal generation in the SIN or, in the case of hydropower, at the current differences settlement price (PLD) in the case of hydropower (see section 5.1.2). This modality is characterized as exceptional, since it's a temporary solution.

In addition to the SIN interconnections, there are also 200 MW interconnections with Venezuela and the Roraima grid, which is not part of the SIN. The interconnection with Venezuela was established to import energy from the El Guri hydroelectric power plant as part of a binational project between Eletronorte and Venezuela's Edelca (now Corpoelec). Roraima is the only Brazilian state that is not yet part of the SIN, yet there are plans to connect it through the Boa Vista and Manaus interconnection. Although the project was approved and auctioned by the ANEEL in 2011, construction has not started.

Brazil imports gas for electricity generation via pipelines from Bolivia and Argentina, and imports LNG from the international market.

13 EPE (2018b)

5 The Electricity Market

5.1 The Wholesale Market, Prices, and Liquidity

5.1.1 The Wholesale Market Design

Brazil's interconnected transmission grid covers an area as large as continental Europe (see Figure 2.1).

In order to ensure security of supply, all electricity consumption has to be backed by firm Power Purchase Agreements (PPAs). These financial instruments have to be tied to a "physical guarantee" (see box) that limits the amount of electricity (per technology type) that can be sold via PPAs. The physical guarantee thus represents the amount of energy that can be delivered under a pre-defined degree of reliability. The CCEE, which manages the wholesale market, records all PPAs for the purposes of accounting and financial settlements.

Box: The Physical Guarantee and the Energy Relocation Mechanism (MRE)

The **physical guarantee** is the maximum monthly amount of energy in MWh that a generator is allowed to sell via contracts. It is a critical measure of a power plant's feasibility.

The methodology, which is used to determine the amount of the physical guarantee certificates issued for each power plant, is complex and depends on the energy source and technology. In the case of thermal power plants, the physical guarantee is determined by the plant's installed capacity, fuel availability, and downtime for maintenance. A derating factor, based on the plant's variable operating costs and inflexibility characteristics, also figures into the equation. In the event that these underlying parameters change, the physical guarantee can be revised.

For intermittent wind and solar energy projects, the physical guarantee represents the minimum amount of electricity that can be generated with a probability of 90 per cent in the case of wind power and 50 per cent in the case of solar energy, as estimated by independent resource assessment studies.

In the case of hydropower projects, the physical guarantee reflects the plant's sustainable energy generation capacity during dry periods. Specifically, it represents the energy that the plant is expected to generate with a minimum probability of 95 per cent, based on past data regarding hydrology and dry period duration.

To protect hydropower plants from hydrological risks, Brazil introduced a structural hedging instrument known as the **Energy Relocation Mechanism (MRE)** that takes advantage of the complementary hydrological conditions throughout the country by treating hydropower plants as a common pool. The MRE scheme reassigns the total physical energy production to the participating hydropower plants based on their share in the total physical guarantee, regardless of their individual production. The regulation requires that the individual physical guarantee for each hydropower plant be revised every five years to reflect changes in generation capability. In order to protect investors from unexpected changes, reductions are limited to 5 per cent of the original value per adjustment and to 10 per cent of this value over the entire 30-year concession period.

The grid is operated centrally by the ONS, which is responsible for physical dispatch across the entire system. This approach makes use of regional and seasonal complementarity and minimizes operational costs.

Though financial revenues for power plant owners are primarily determined by their PPAs and the underlying physical guarantees, the ONS operates as if all plants belonged to the same owner. It uses a suite of computational models to determine the most efficient hourly production schedule for each plant on a least operational cost basis, where variable renewables with low operational costs (typically wind and solar) receive dispatch priority. Hydropower plants are dispatched on the basis of their expected opportunity cost (or "water values"), which are computed using a complex, multi-stage, stochastic optimisation model that produces a detailed representation of each plant's operation and inflow uncertainties. The objective is to maximize the flexibility capacity of hydropower by maintaining available water reservoirs at a secure level for future generation.

Thermal plants, for their part, must publish variable operating cost (VOC) reports. The ONS uses the VOCs to calculate the probable future marginal operation cost (MOC) of the system. Thermal plants are dispatched whenever the calculated MOC surpasses their VOC. The aim of this approach is to organise the dispatch of all available resources in a way that minimises the system's total risk-adjusted operating costs over the next five years.

Since the ONS's centralised dispatch system is based on long-term cost minimization and not on contracted generation figures, there are often significant differences between the amount of electricity supplied and the amount contracted. These differences are settled in the short-term market (MCP), which is in fact not a real market but a financial mechanism (see section 6). Agents that are unable to produce or use the amount of energy that they have contracted, or that have generated electricity in excess of their contracted physical guarantee, must liquidate these differences at the centrally defined differences settlement price (PLD) (see section 5.1.2). The MRE (see box) hedges the individual hydrological risk of each hydropower plant across the entire pool of hydropower plants.

Should unfavourable hydrologic conditions occur that affect the entire pool of hydropower plants – bringing the total energy generation of the pool below the aggregated physical guarantee – a so-called Generation Scaling Factor (GSF) is applied, and the energy shortfall must be compensated at current PLD values. The related costs must be borne by individual plant operators based on their share in the MRE. This means that the MRE scheme cannot protect hydropower plants from systemic hydrological risks, such as prolonged periods of drought, that impact the country's hydropower portfolio as a whole.[14]

The Brazilian market is based on wholesale competition. The gradual implementation of retail competition proposed as part of the first sectoral reform in 1995 was abandoned. Today, only large consumers with a demand in excess of 3 MW are able to choose their supplier. The current proposal for power sector reform aims at retail competition for all consumers (see section 11).

Since 2004, electricity has been commercialised in two different contractual environments: the regulated market (ACR) and the free market (ACL).

The following table 5.1 summarises the characteristics of the two markets.

14 According to the stochastic model that determines the physical guarantee for hydropower, a shortfall of the whole pool in generation highly unlikely under normal circumstances. However, the MRE has experienced generation deficits since 2013, which have caused a large financial deficit for hydropower operators and Brazil's energy industry as a whole. This situation is a key driver for the proposed reform of Brazil's electricity market regulation.

Description of the regulated market and the free electricity market Table 5.1

	ACR	ACL
Agent type	Utility companies, distributors, traders (only in A-1 and adjustment auctions for existing power plants)	Utility companies, traders, free and special consumers
Contract type	Energy PPAs, regulated by the ANEEL	Bilateral contracts
Price definition	Prices reached via auctions; price caps are calculated by the EPE and sanctioned by the ANEEL for each technology prior to auction	Based on bilateral negotiations; PLD serves as a guide

Authors' own illustration

About the ACR

In the regulated market (ACR), consumers purchase their electricity from local electricity distribution utilities. In order to enable competition and enhance cost efficiency, distribution companies are obliged to buy their electricity via government auctions. These auctions are organised by the MME and conducted by the ANEEL. The MME specifies the guidelines for each auction, including the contract type offered, contract indexation, and lead time. The auctions contract energy that is to be delivered "x" years ahead and are known as "A-x" auctions, where "x" stands for the delivery year. Existing and new power plants compete in different auctions. The MME divides up the volumes that are to be contracted between the different generation technologies.

The main auction types in the ACR are as follows:

1. Existing energy auctions (LEE), which assign power purchase agreements (PPAs) for up to 15 years. Only existing power plants can participate in this type of auction, which is intended to renew distribution companies' present contracts and reduce the risk of price increases. Delivery begins in the same year or up to two years after the auction date. (A/A-1/A-2)
2. New energy auctions (LEN), which assign long term PPAs of up to 30 years for delivery in 3 to 6 years or longer. New energy auctions take place at least twice a year to ensure that the power system grows in line with the expected growth in demand.
3. Adjustment auctions (LA) for short-term PPAs that are to be delivered in the same year. These are carried out four times a year in order to enable distributors to make short-term adjustments to match demand.
4. Auctions for alternative energy sources (LFA), which are restricted to renewable energy sources in order to increase their contribution to the national power mix.

Apart from the above auctions, which exclusively concern the ACR, the government sporadically conducts reserve energy auctions (LER) to guarantee the security of the electricity supply or promote specific energy sources. PPAs from LERs do not have to be tied to physical guarantees. The costs of reserve energy are divided among all of the consumers in both markets (ACR and ACL) via a system charge (see section 5.2.1).

There are two types of electricity contract in the ACR:

1. Energy quantity contracts: These are financial forward contracts, which commit generators to delivering a fixed amount of energy over a defined period at a given price per MWh. This type of contract is usually used for hydroelectric generation in Brazil. The hydrological risks and variations in the

plant's generation costs are borne by the generator.[15]

2. Energy availability contracts: in these contracts, generators make their plant's generation capacity available and receive a fixed revenue in return. When these plants are dispatched, distribution companies take on the variable (fuel) costs for generation and the potential imbalance settlement costs or revenues. Plants contracted via availability contracts (most of which are thermal and wind power plants)[16] are dispatched by the ONS based on the combination of merit order rules and the maximisation of security of supply; these contracts resemble energy call options[17].

Because of the governmentally coordinated long-term energy sales arrangements to a diversified pool of distribution companies, the ACR has been effective in promoting the expansion of Brazil's power generation capacity with new investments. Based on these long-term energy sales contracts, the Brazilian Development Bank BNDES has been offering attractive financing packages that were especially effective in promoting capital intensive renewable energy investments.

About the ACL

In the free market (ACL), consumers with a minimum demand of 3MW (free consumers) can purchase their electricity directly from generators and traders. In order to promote renewable energy sources, consumers with a minimum demand of 500 kW (special consumers) are also allowed to participate in the ACL, as long as they purchase their electricity exclusively from such sources. Energy prices and contract terms and conditions are negotiated bilaterally in the ACL.

In 2017, the ACL accounted for almost 30 per cent of national electricity consumption and 77 per cent of industrial electricity consumption. 30 per cent of the energy traded in the ACL derived from renewable energy sources.

While ACL contracts are attractive for both consumers and generators, they are usually limited to a maximum of 3 to 5 years and it is therefore difficult to develop capital intensive renewable energy investments that require long and secure energy sales arrangements to be financially viable for equity investors and their financing banks. As a result, more attractive short-term ACL contracts are often used to complement the long term ACR revenues.

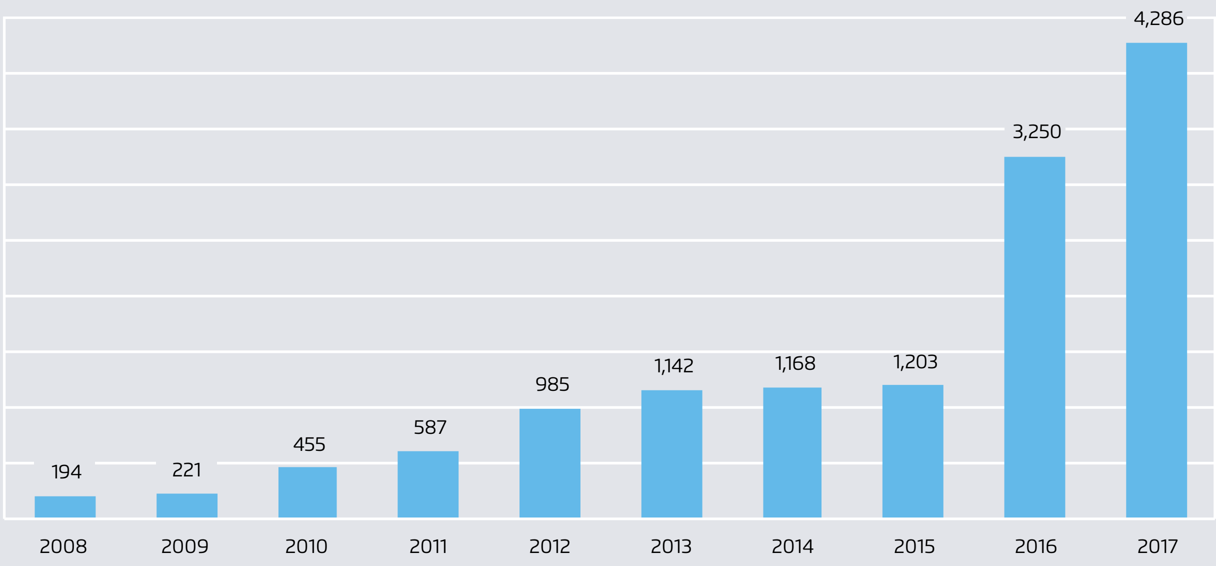
By the end of 2017, there were 5,158 consumers in the ACL, of which 872 were free consumers and 4,286 special consumers. The number of special consumers has increased significantly over the last few years, as shown in Figure 5.1.

15 In 2012, the government renewed the concessions for operating a significant share of Brazil's existing hydropower plants. As these plants had been build decades ago, their investments were largely amortized and new concessions were issued under a quota regime that only reimburses costs for Operation and Maintenance. Objective of this arrangement was to reduce the end consumer electricity tariff in line with an election pledge from the Dilma Rousseff administration. At the same time, however, responsibility for these plants' hydrological risks was transferred to end consumers (provisory legal measure MP 579/2012).

16 Availability contracts have been adapted to take into account the specificities of different energy sources. In the case of wind power, the key change has been to introduce a tolerance band that serves to transfer the risks related to wind conditions from individual entrepreneurs to the system itself. Where thermal biomass, such as sugarcane bagasse, is concerned, contracts have been adapted to allow for monthly variations in plant availability, in light of the greater availability of bagasse during the harvesting period.

17 The ONS can order plants to dispatch out of the merit order to enhance the systems reliability and security, which has been frequent in recent years due to water scarcity and a higher share of intermittent wind generation in the north-east region. Fossil fuel based peak load units have been operated heavily to ensure the systems reliability.

Number of special consumers in the ACL (2008–2017) Figure 5.1



ABRACEEL (2018)

5.1.2 Wholesale Market Prices

Electricity prices in the ACR are established via government energy auctions (see 5.1.1). Distribution companies declare the amount of energy demand that they project for their concession area and the auction announcement calls for offers corresponding to the aggregated demand of multiple distribution companies. After the collective auction, each distribution company signs an individual contract with the electricity generator.

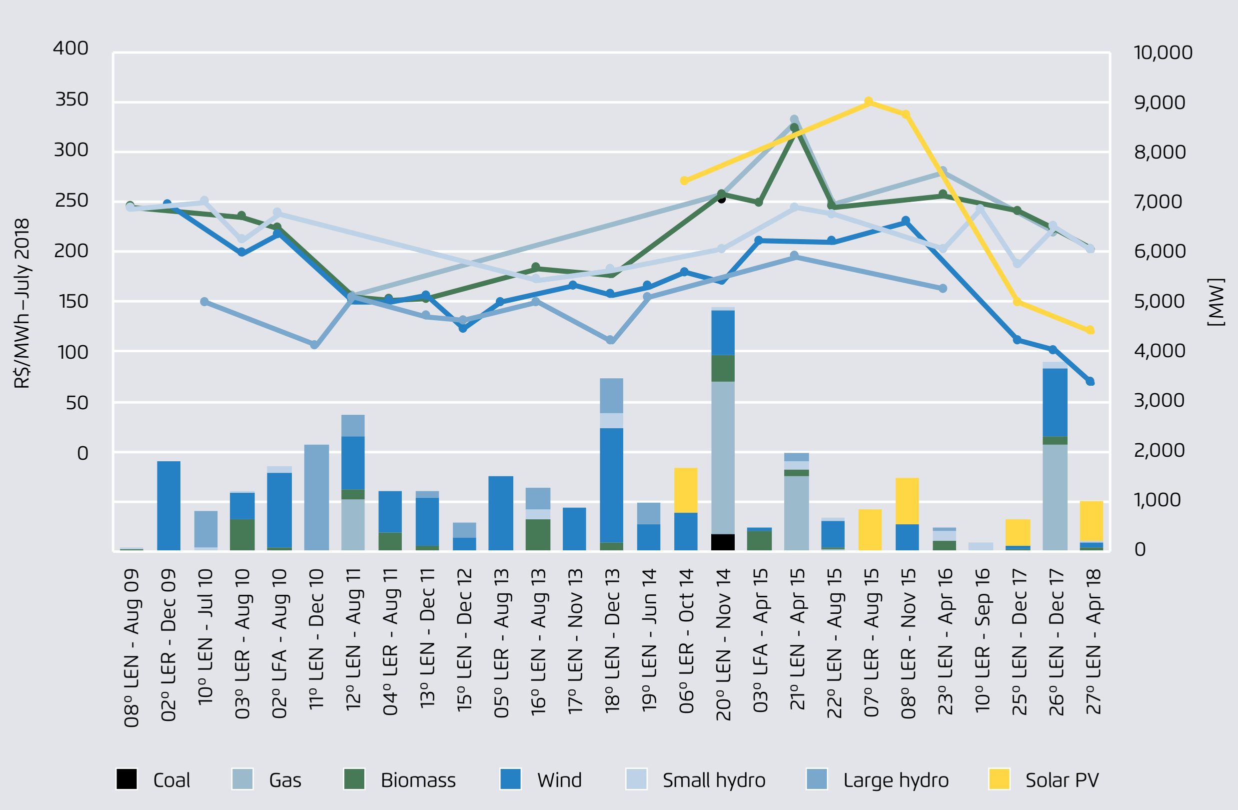
For over 12 years now, the Brazilian auction mechanism has been based on a hybrid system that combines a descending-clock-model (phase 1) with a pay-as-bid model (phase 2). Bidders confirm the amount of electricity they are willing to offer at the auction's ceiling price, which is set separately for each technology prior to the auction. The auctioneer gradually lowers the price until just enough energy has been offered to supply the pre-defined demand, plus an extra margin to allow for competition in the second phase. In the second phase, bidders offer their energy at a final price that cannot be higher than the price disclosed in the first phase of the auction. Bidders that offer the lowest prices are awarded long-term PPAs. In 2017, this mechanism was changed to a sequential and iterative sealed-envelope pay-as-bid auction, based on clock rounds.

Figure 5.2 shows inflation adjusted average prices per energy source in government energy auctions since 2009 and installed capacity by source.

Figure 5.2 does not include the results of so-called structuring auctions, which are held for strategic projects of public interest and implemented by means of concessions. Between 2007 and 2013, concessions for a total of six large hydropower plants with an overall installed capacity of 20.6 GW were awarded over the course of four structuring auctions: Santo Antônio (3,150 MW), Jirau (3,300 MW), Belo Monte (11,233 MW), Teles Pires (1,820 MW), Sinop (400 MW), and São Manoel (700 MW). The prices of these hydropower plants are very site specific and subject to particular incentive packages, such as BNDES financing or the selling of electricity in the ACL.

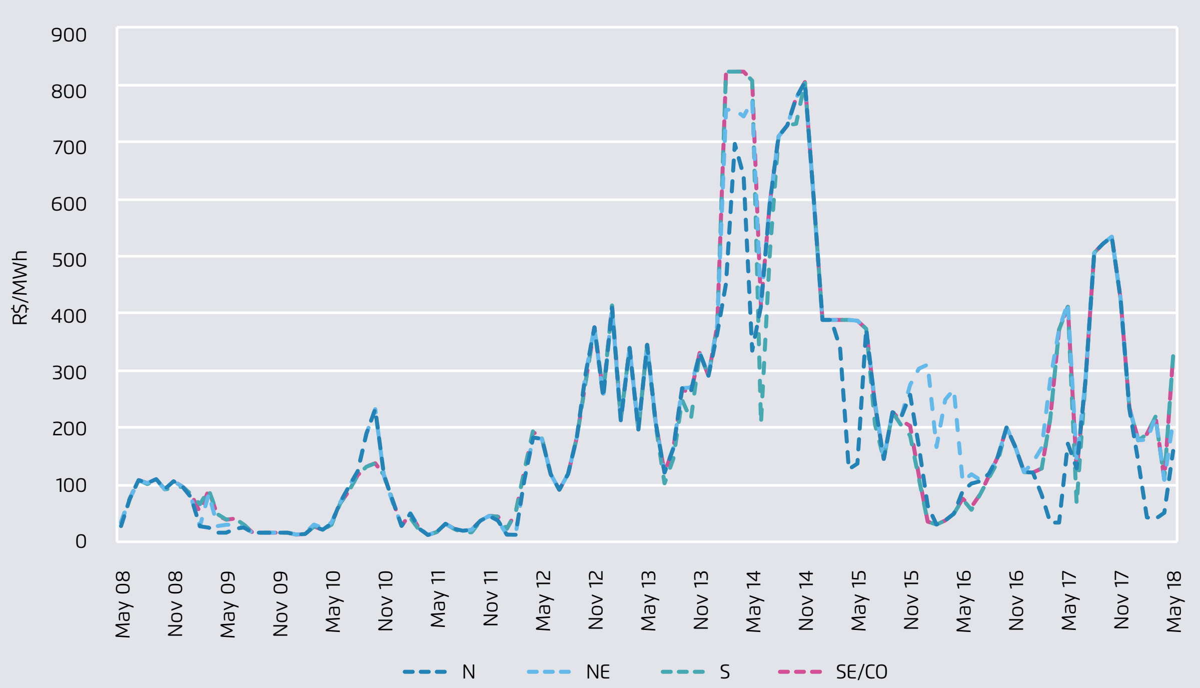
Due to the obligation to back all demand by PPAs, the role of the spot market in Brazil is limited to the balancing of contractual differences with respective generation or consumption levels. Therefore, the price that comes closest to a spot market price in the Brazilian electricity sector is the differences settlement price (PLD), which the CCEE updates weekly for light, medium, and heavy load levels in each of the four subsystems of the SIN. The PLD is the clearing price at which differences between the amount of energy produced and the amount contracted are settled. The CCEE calculates the PLD on the basis of the „ex-ante" dispatch, using forecasts of plants' availability and consumption for the next week. The NEWAVE and DECOMP computational models, which are also used by the ONS to operate the system as a whole, are used to estimate the hypothetical optimal dispatch of each power plant in the system, in order to calculate the probable marginal operating costs (MOC) for the week ahead. The PLD is therefore calculated on the basis of forecasts rather than on real market data. The model has been strongly criticised due to the perceived sig-

Average prices achieved by energy source in auctions from 2009–2018 (per installed capacity) Figure 5.2



Authors' own illustration, based on data from CCEE (2018b)

Monthly average PLD values in R$ per MWh (2008–2018) — Figure 5.3



CCEE (2018)

nificant differences between the PLD and the real marginal operating cost of the system, which serves to distort price signals for market players.[18]

Since 2015, the ANEEL sets an annual floor and ceiling for the PLD. The calculation of the maximum PLD takes into account the variable operating costs of the thermoelectric plants available for centralised dispatch. The minimum PLD value is based on the operating and maintenance cost of hydroelectric plants and the CFURH sectoral charge for the use of water resources (see section 5.2.1).

Figure 5.3 shows the development of the PLD from 2008 to 2018 for each of the four subsystems. The relatively high prices since 2013 are, among other aspects, a result of a prolonged unfavourable hydrologic conditions.

18 Zanette (2013)

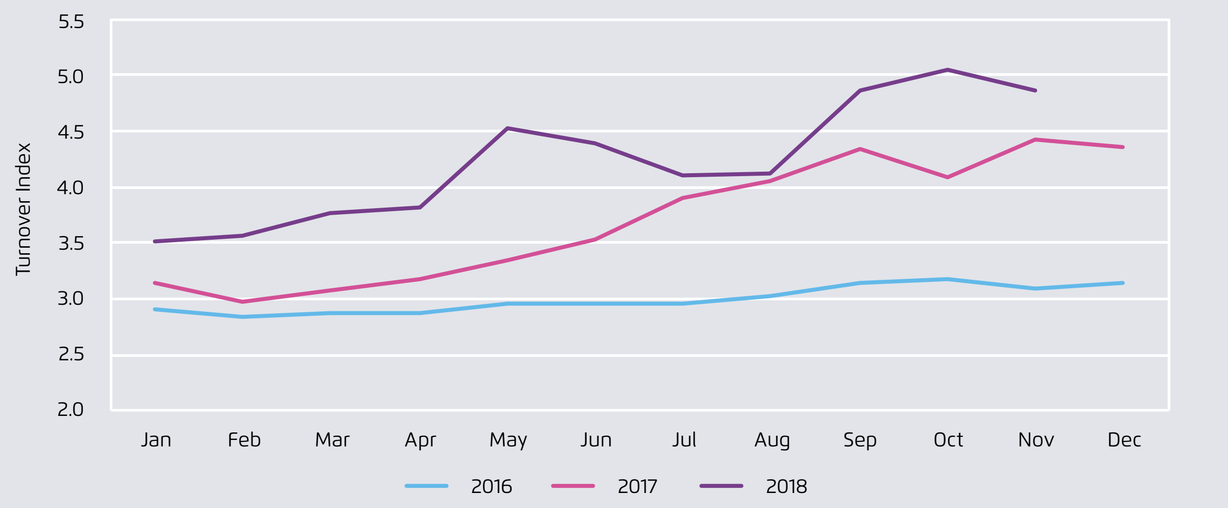
Prices in the ACL are agreed on bilaterally and are not made public. Companies that offer to migrate large consumers to the ACL advertise considerable cost reductions, depending on the concession area. Contracts in the ACL usually run for up to 5 years, which is why generators that require financing prefer to commercialise their power plant´s electricity in the ACR.

5.1.3 Market Liquidity

The Herfindahl-Hirschman Index (HHI)[19] is not published on a regular basis for the Brazilian power sector. In 2011, PwC published a study that

19 The HHI is defined as the sum of the squares of the percentage market share of each market player. The index can range in value from 0 to 10,000. The higher the index, the more concentrated the market. A market with an HHI of less than 1,000 is generally considered competitive, while a market with an HHI between 1,000 and 1,800 would be considered moderately concentrated, and a market with an index above 1,800 would be considered highly concentrated.

Turnover index for the ACL — Figure 5.4



Authors' own illustration, based on data from CCEE (2018a)

included HHI figures for generation (1,500), transmission (1,100) and distribution (780).

The CCEE evaluates the liquidity of the ACL using a turnover index, which is based on the relationship between the total volume of electricity traded by ACL agents and the total volume of purchase contracts concluded by all ACL consumers. Figure 5.4 shows the upward trend of the turnover index from 2016 to April 2018.

Figure 5.5 shows the current market concentration by way of the market shares of the largest companies in the different market segments

The major companies in each segment of the electricity sector — Figure 5.5

Sector	**Market agents**	**Market shares**			
Generation by installed capacity [a]	4908 utilities	31% Eletrobras	21% 10 Major comp. exc. Eletrobras	48% Other companies	
Transmission by lines lenght [b]	77 concessionaires	52% Eletrobras		39% 7 Major comp. exc. Eletrobras	9% Other companies
Distribution [a]	63 concessionaires	58% 10 Major companies		42% Other companies	
Commercialisation [b]	1472 retailers	41% 7 Major companies		59% Other companies	

Sources: (a) ANEEL (2017a); (b) Bank of America (2017)

5.2 The Retail Market

As of December 2017, there were a total of 82.3 million customers in the ACR, most of which were households, small businesses, and industrial firms. In the same year, electricity consumption in the ACR totalled 313.6 TWh, or 67.6 per cent of national electricity consumption.[20]

ACR customers are called captive consumers, since they have no choice about where to purchase their electricity. The local distribution company supplies them at the electricity tariff defined by the ANEEL. Table 5.2 shows electricity consumption in the regulated market, along with the number of consumers by sector and their respective market shares.

The Brazilian tariff system is relatively complex. The ANEEL sets and annually adjusts electricity tariffs for end consumers in the regulated market for each of Brazil's 63 concession areas. In order to do so, it uses a complex methodology (RPI-X) that aims to strike a balance between fair prices for consumers and adequate remuneration for distribution companies. As a result, the medium electricity tariff (including tax) is currently 0.380 R$ per kWh in the cheapest distribution area and 0.643 R$ per kWh in the most expensive area[21] (as of May 2018).

Electricity prices have significantly increased for a wide range of consumers over the last decade, and have come to diverge from the consumer price index in the last few years. Figure 5.6 shows how average Brazilian electricity tariffs have developed over the past decade relative to the overall price increase, as indicated by an inflation index for the same period (starting with a baseline of 100 in January 2008).

In accordance with an election pledge, the government reduced electricity tariffs in 2013 by an average of 20%. The level of the reduction was set in response to a range of conditions and assumptions, but proved to be unsustainable. The situation worsened as a result of challenging hydrological conditions: a period of severe droughts led to exceptionally high use of

20 EPE (2018c).

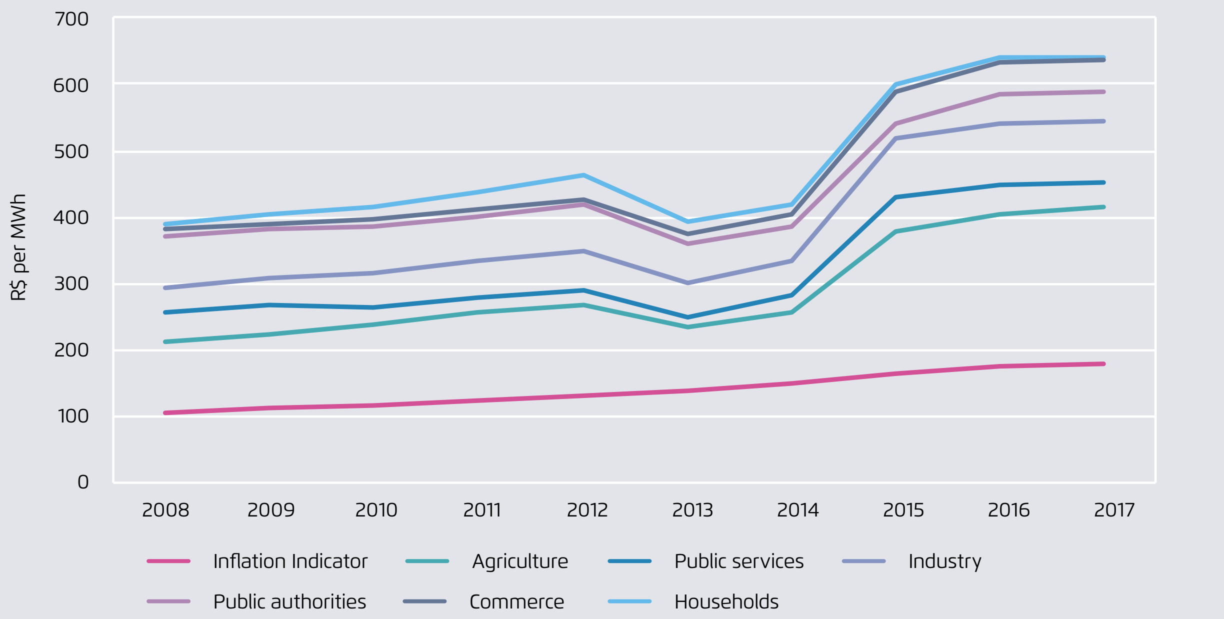
21 In addition to the 63 distribution concessionaires, there are several other licence and authorisation holders, mainly consisting of rural cooperatives, which are responsible for electricity distribution in remote areas. As of 2016, there were 52 such cooperatives, which are regulated by the ANEEL. Electricity tariffs in these areas ranged from 0.309 to 0.765 R$ per kWh as of May 2018.

Electricity consumption and number of consumers in the ACR – December 2017 — Table 5.2

Sector	Electricity consumption in GWh (2017)	Market share	Number of consumers (2017)	(Share)
Households	136,773	43.6%	70,565,076	85.75%
Commerce and services	73,418	23.4%	5,748,690	6.99%
Agriculture	24,487	7.8%	4,670,686	5.68%
Public authorities	14,864	4.7%	578,768	0.70%
Industry	35,583	11.3%	526,240	0.64%
Public lighting	15,603	5.0%	100,438	0.12%
Public services	12,406	4.0%	96,187	0.12%
Own consumption	474	0.2%	9,280	0.01%
TOTAL	**313,608**	**100%**	**82,295,365**	**100%**

ANEEL (2018d)

The inflation index and average Brazilian electricity tariffs (including tax) by consumer type — Figure 5.6



ANEEL (2018d) and IBGE (2018)

expensive thermoelectric power generation, which caused electricity tariffs to soar in 2015 and increase again in 2016. Prices rose by an average of 46.3 per cent between 2012 (prior to the extraordinary reduction) and 2017. In 2015, the government introduced a new tariff component to reflect the extraordinary temporary costs and conditions of electricity generation (see 5.2.1).

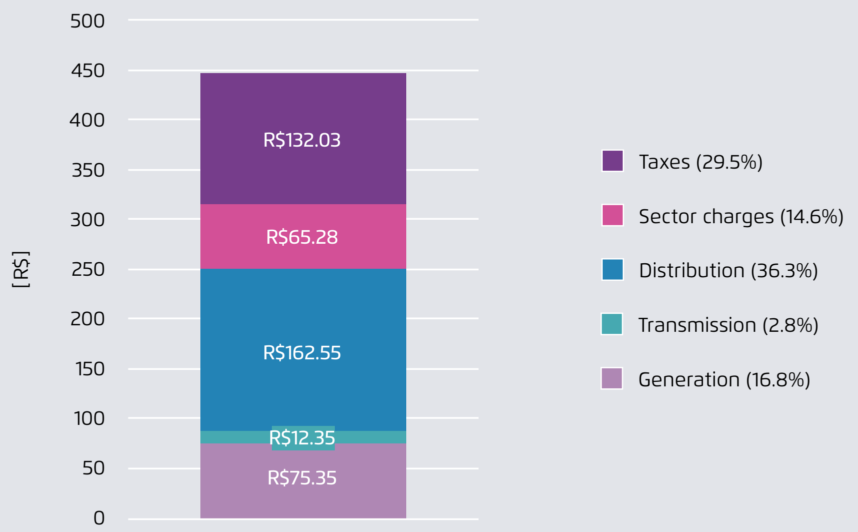
As noted in section 5.1.1, the ACL is restricted to free consumers with a minimum demand of 3 MW and special consumers with a minimum demand of 0.5 MW who opt to purchase electricity from incentivised sources (i.e. from alternative renewables and cogeneration). In order to facilitate the migration of smaller consumers to the ACL, changes have been introduced to allow several consumption units registered under the same tax account number to be pooled (RN 570/2013). These consumers can be served by so-called retail traders. Take-up has so far been limited: as of February 2018, there were only nine companies operating as retail traders, serving a total of 26 consumer units.

5.2.1 A Breakdown of the Brazilian Electricity Bill

The electricity bill paid by ACR consumers includes costs for generation, transmission, and distribution, along with sectoral charges and taxes.

The ANEEL sets the electricity tariff using a complex methodology that takes into account the various factors affecting the cost structures of the different service providers. State and municipal taxes also need to be incorporated separately for each distribution company. As a result, there is considerable variation between the electricity prices paid by end customers in each of the 63 concession areas. Figure 5.7 provides a breakdown of the average Brazilian electricity tariff in 2015.

Breakdown of the average electricity tariff (2015) — Figure 5.7

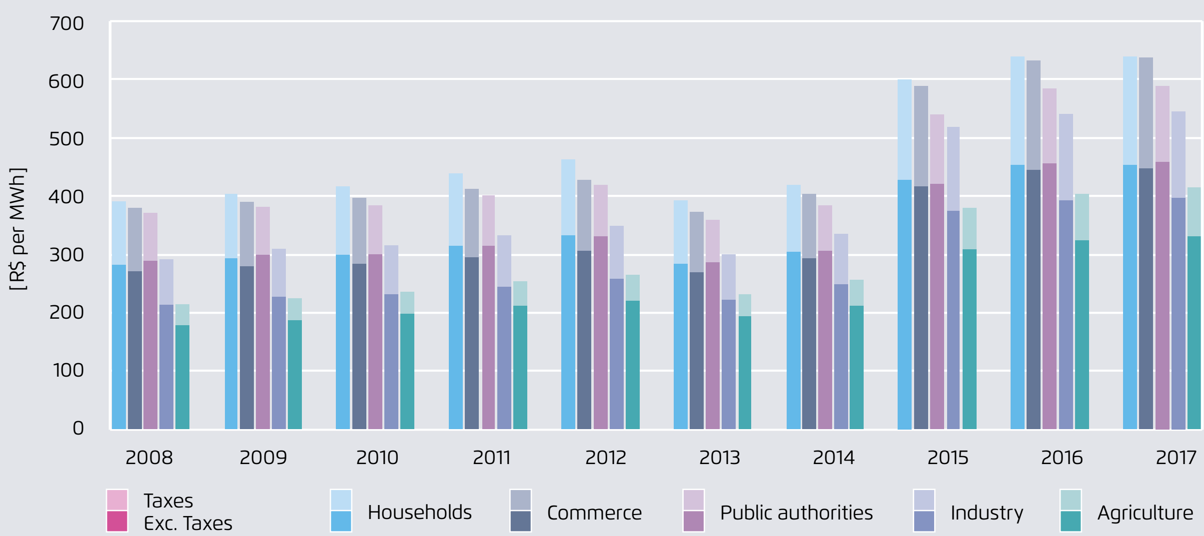


ANEEL (2016)

Figure 5.8 shows the evolution of average electricity tariffs with and without taxes for each consumer type.

The taxes levied on electricity include two federal taxes called PIS (Social Integration Programme) and COFINS (Contribution to Social Security Financing), the ICMS state tax (Tax on the Circulation of Mer-

Evolution of average Brazilian electricity tariffs by consumer type, including taxes (2008–2017) — Figure 5.8



ANEEL (2018d)

Sectoral Charges Table 5.3

Type of charge	Purpose/destination
CDE Energetic Development Account	Promoting alternative energy sources, expanding energy service provision (rural electrification), and providing subsidies for national lignite and low income households
CCC Fuel Consumption Account	Subsidising thermal electricity generation in the Northern region in particular (isolated systems)
PROINFA	Promoting Incentive program for alternative renewable energy sources
RGR Global Reversal Reserve	Reimbursing the cost of assets connected with utility provision and promoting sectoral expansion
ESS System Service Charge	Subsidising SIN maintenance to ensure reliability and stability, covering the costs of constrained on and off generation
CFURH Financial Compensation for the Use of Water Resources	Providing financial compensation for the use of water and productive land for power generation
ONS National System Operator	Covering the operating costs of the ONS
P&D/EE Research and Development and Energy Efficiency	Promoting scientific and technical research on electricity and the sustainable use of natural resources
EER Reserve Energy Charge	Covering the cost of reserve energy in the relevant auctions
TFSEE Electric Energy Service Inspection Fee	Covering the operating costs of ANEEL

Based on Aneel, 2016

chandise and Services), and the municipal COSIP/CIP tax (Contribution for Public Lighting Services).

Sectoral charges are levied for specific purposes defined by the National Congress, such as the implementation of government policies and initiatives. The distribution companies collect these charges from end consumers via their electricity bills.

Table 5.4 shows the main expenses financed by the CDE.

Electricity tariffs are adjusted separately for each distribution company on a regular basis: there is an annual adjustment, a periodic tariff review (which takes place on average every four years), and extraordinary tariff revisions where necessary.

The ANEEL analyses the distributors' costs in two categories:

- → Category A: costs considered "uncontrollable costs", including the costs of purchasing energy, transmission costs, and sectoral charges. These costs are assessed during the tariff readjustment process. Distributors' energy costs depend on the portfolio mix of their purchases in energy auctions.
- → Category B: costs considered "controllable costs" that depend on the distribution company's individual performance, such as operating costs, the depreciation quota, and remuneration for investments. Category B costs are adjusted on the basis of the general price index of the market (IGP-M) and an additional index set by the ANEEL termed "factor X", which reflects the difference between the operator and the average company in the econ-

Destination of CDE revenues (2013–2018) Table 5.4

CDE BUDGET (billion R$)						
Expenses	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Social tariff (low income households)	2.20	2.10	2.17	2.24	2.50	2.44
Rural electrification	2.03	0.88	0.88	0.97	1.17	1.17
National coal subsidies	1.00	1.12	1.22	1.01	0.91	0.75
Alternative sources and gas	–	–	–	–	–	–
CCC–Isolated systems	4.04	4.69	7.22	6.34	5.06	5.35
Discounts on distribution (TUSD)	4.46	4.09	5.45	6.16	6.05	6.94
Concession compensation	–	3.18	4.90	1.24	–	–
Other expenses	2.41	2.90	4.29	2.55	1.48	3.36
Total	**14.12**	**18.07**	**25.25**	**18.29**	**15.99**	**18.84**

ANEEL (2018)

omy with respect to inflation in input prices and changes in productivity.

In order to account for currency variations, a compensation account was created for category A items (CVA). The CVA registers variations during the period from one readjustment to another.

The periodic adjustments that occur every four years are based on a methodology involving a reference company, which is intended to stimulate operational efficiency and adequate investment.

Two different tariffs are available to group A consumers (i.e. large consumers and industrial and large commercial consumers that are connected to the medium and high-voltage grid), depending on their individual consumption profile.

→ Blue tariff: includes different demand prices per kW (peak and off peak) and four different kWh prices depending on the time of day and the season (peak and off peak/wet and dry season).

→ Green tariff: includes a single demand price per kW and four different kWh prices depending on the time of day and the season (peak and off peak/wet and dry season).

Connection to the low voltage grid for group B consumers is charged on the basis of a minimum consumption level known as the availability cost. This is 30 kWh for mono-phase connections, 50 kWh for bi-phase connections, and 100 kWh for three-phase connections. The availability cost cannot be reduced to zero within the existing net metering scheme, nor by saving energy by, for example, shutting off all energy consumers during longer holidays.

Since January 2018, an additional tariff, known as the white tariff, has been available to group B consumers with consumption levels above 500 kWh. The white tariff is a time-of-use tariff that differentiates between peak load and off-peak hours, in order to discourage electricity usage during peak times. The white tariff will gradually be extended to all type B consumers by 2020. Consumers who opt for this tariff will have their conventional meters replaced by a smart meter, with distributors being responsible for the replacement costs (see 10.3).

Low-income households can apply for a "social tariff", which offers discounts of up to 65 per cent on the conventional electricity tariff, depending on consumption.

In 2015, the government introduced a system of "flags" to inform end consumers about cost variations due to prevailing generation conditions within the SIN. These variations may result from temporary hydrological conditions or the cost of foreign currencies, which can affect the cost of fossil fuels. The green flag indicates favourable conditions. The yellow flag indicates less favourable conditions and the red flag unfavourable conditions, both of which involve additional charges.

5.3 Allocation of Grid Costs

Grid costs for transmission and distribution are passed on to the end consumer. Generators, distribution companies and large free market consumers that are connected directly to the transmission grid (i.e. that have installations and facilities operating at voltages greater than 230 kV) are charged for transporting electricity under the Use of Transmission System Tariff (TUST).

The methodology used to calculate the TUST is based on long-run marginal cost pricing (as adopted in the UK). It was elaborated by the ANEEL[22], which also adjusts the tariff on an annual basis. The TUST consists of several components. The main component is the TUST-RB, which is levied on all users and covers the installation costs for the basic transmission grid at 230 kV or above. The TUST-RB is calculated using the Nodal Program. This program calculates the transmissions costs, considering the accessing party's connection point. The second component is the TUST-FR, which consists of charges for the servicing of transformation units and is applied to distribution companies according to their specific usage.

22 Normative Resolution REN N° 559/2013

The TUST-FR covers the cost of all busbars under 230 kV. The transmission tariff for the binational Itaipu power plant is calculated separately and is only paid by Itaipu shareholders. Electricity importers and exporters are subject to a special transmission fee called TUST exp/imp, along with charges for the use of the installations required for international electricity exchange, termed TUII.

Captive ACR consumers and free ACL consumers that are connected to the distribution grid are charged through the Use of Distribution System Tariff (TUSD). The TUSD can be split into two components: the TUSD Fio, which covers the operating costs of the distribution system, and TUSD charges, which include sectoral charges and fees. The TUSD is detailed on consumers' electricity bills.

Transmission line concessions are offered by the ANEEL on a 30-year basis. There are currently 77 transmission companies in the SIN. 47% of the transmission lines are owned by Eletrobras and its subsidiaries.

Transmission companies are remunerated on the basis of Allowed Annual Revenues (RAPs). The RAPs are determined by the transmission auctions: the maximum RAP value is published in the auction notice and the company that offers the lowest RAP wins the auction. Each company's RAP values are adjusted by the ANEEL on an annual basis. From July 2017 to June 2018, the RAPs of all 77 transmission concessionaires totalled 23.7 billion Reais.[23]

In 2017, the annual revenues of the distribution companies totalled 132 billion Reais.[24]

23 ANEEL (2017b)

24 ANEEL (2018d)

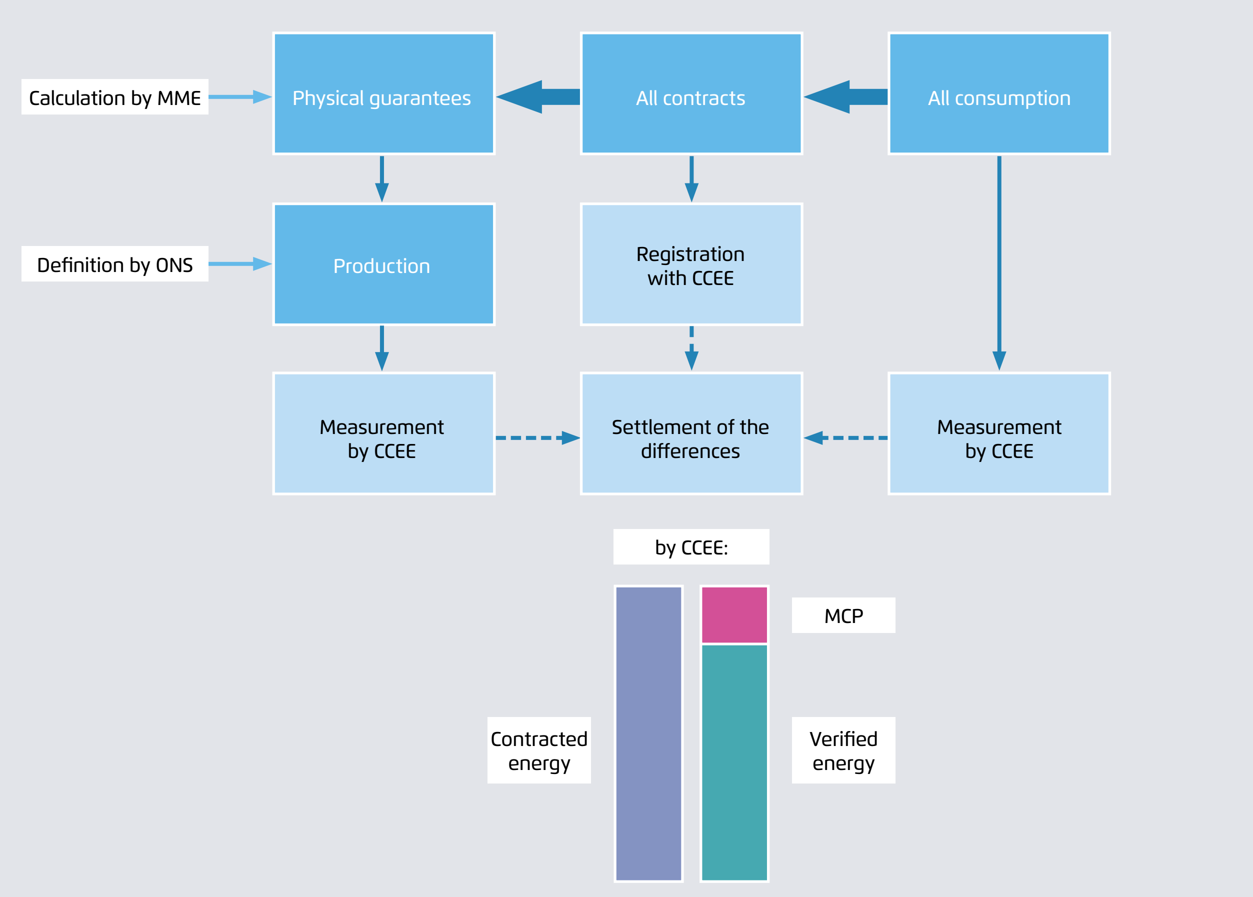
6 Electricity Balancing/Reserve Markets

The operational balancing of the national grid (i.e. the management of supply and demand) falls under the remit of the ONS, which manages electricity dispatch centrally. The ONS determines each plant's dispatch using the NEWAVE and DECOMP computational optimisation models in order to use the energy sources in the SIN as efficiently as possible and ensure the future availability of energy. The ONS can therefore dispatch generators outside the merit order and physical dispatch does not necessarily reflect the contracted volume (see section 5.1.1). Grid operation is planned on an annual and monthly basis, and is updated weekly and daily.[25]

The financial liquidation and settlement of both the ACR and the ACL is undertaken by the CCEE in the so-called short-term market (MCP) on a monthly basis. The MCP is a financial settlement mechanism rather than a true market. All contracts from the ACR and the ACL are registered with the CCEE and are

25 ONS (2018)

Illustration of the settlement process — Figure 6.1



CALABRIA, SARAIVA (2014)

taken into account in the settlement process. Once a month, buyers from the ACR[26] deposit a sum equivalent to the energy they have consumed into a bank account managed by an ANEEL-appointed financial agent. In accordance with the contracts in its database, the financial agent then transfers these sums to the relevant sellers the following day. Differences between the contracted volumes and the consumed volumes are settled at PLD values.

26 In the ACL, the contracted energy is liquidated bilaterally, while the differences between the energy consumed and the energy contracted are settled via the MCP, using the same rules as for the ACR.

7 Long-Term Energy and Decarbonisation Policies

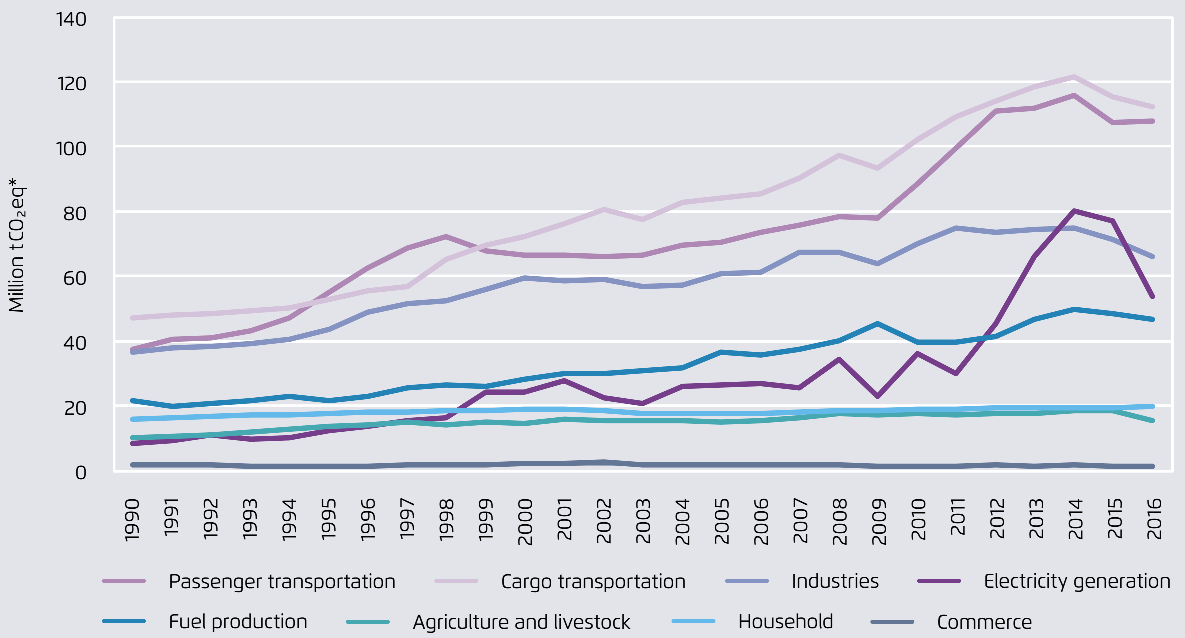
Brazil's main commitments concerning the decarbonisation of its energy matrix stem from the NDCs[27] ratified by the government in 2016. These provide for a 37% economy-wide reduction in GHG emissions by 2025 and an indicative reduction of 43% by 2030.[28] In the energy sector, the indicative target provides for a 45% share of renewables in the energy mix by 2030. In the electricity sector, the NDCs indicate the country's intention (rather than its obligation) to increase the overall proportion of renewable energy sources (other than large hydro) to at least 23% by 2030. Where electrical energy efficiency is concerned, the NDC provides for a 10 per cent reduction against estimated business as usual consumption in 2030.

Energy use accounts for the fastest growth in CO2 emissions in Brazil. Since 2012, energy use has been the second-largest source of GHG emissions, just behind land use, land use change, and forestry (LULUCF). According to the SEEG (2018), the economic activities accounting for the most significant energy-related emissions in 2016 were: passenger transportation (25%), freight transport (26%), industry (16%), and electricity generation (13%). As a result of

27 The Intended Nationally Determined Contribution (iNDC) was established on the back of the Paris Agreement in December 2015, and indicates the efforts in greenhouse gas emissions reductions that the country intends to make to mitigate its impact on climate change. Following the ratification of the Agreement on September 2016, the iNDC is now binding.

28 In comparison with 2005.

Development of GHG emissions relative to fuel combustion by sector in CO_2eq — Figure 7.1



SEEG (2018) — * According to GTP AR5

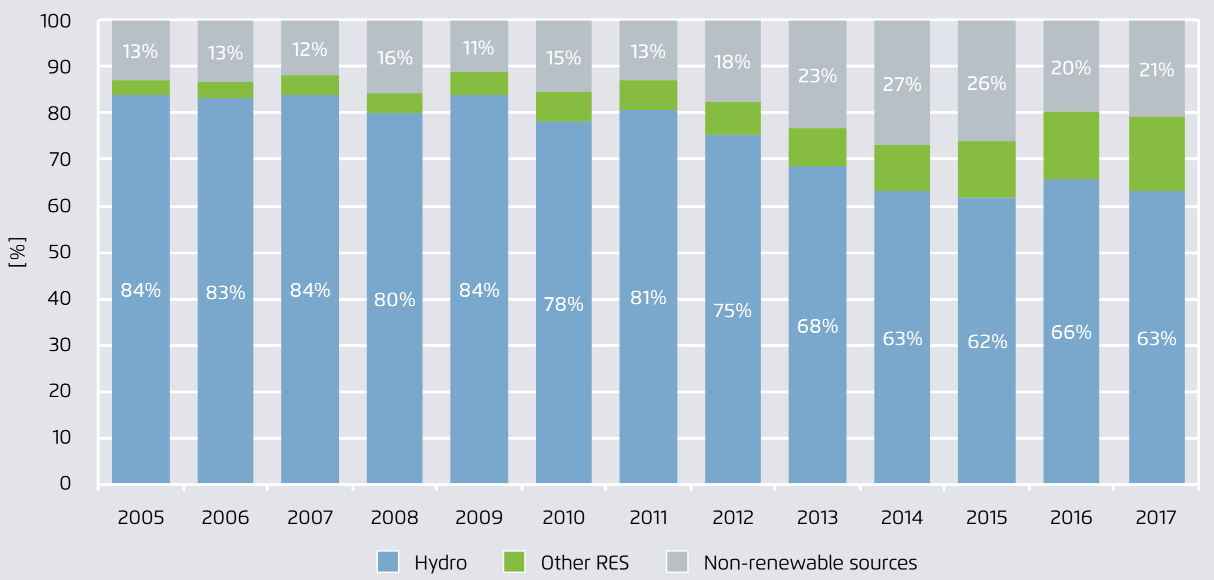
the hydrological crisis, emissions resulting from electricity generation rose sharply after 2011, as shown in Figure 7.1.

The Brazilian electricity mix is considered relatively clean. Nevertheless, Brazilian energy consumption continues to rise. Given the constraints for new hydropower and the projected availability of large volumes of natural gas, maintaining or reducing the sector's GHG emission levels will be a challenge. The expansion and integration of renewables – by, say, electrifying the transport fleet, the industrial sector, and urban spaces – will be crucial in order to lower emissions in industry and transport.

The electricity system relies heavily on large hydropower plants, backed by fossil fuel thermal generation during dry periods. Figure 7.2 shows the evolution of fossil fuel vs. renewable electricity generation over the past decade.

Renewable and non-renewable electricity generation as a percentage of total generation (2005–2017)

Figure 7.2



EPE (2018)

8 Alternative Renewable Energy Sources

8.1 Centralized renewable electricity generation

In 2017, alternative renewable energy sources (i.e. small hydropower, wind, solar, and biomass) accounted for 16 per cent of national electricity generation. Large hydropower still dominates the Brazilian electricity mix and made up 63 per cent of all electricity generation in 2017. By 2050, demand for electricity in Brazil is expected to more than triple. New large hydropower plants are increasingly difficult to implement on account of the prevailing social and environmental constraints, as well as their capital intensity and long construction periods. Moreover, the unfavourable hydrology observed over the recent years highlighted the importance of diversifying the generation mix. In this context, the expansion with a portfolio of alternative renewable sources with decreasing cost offer the opportunity to align the objectives of security of supply, cost efficiency, and low GHG emissions in the medium-to-long-term.

Long-term planning for Brazil's energy sector is set out in two documents drawn up by the EPE: the long-term National Energy Plan for 2030 (PNE 2030), which was last updated in 2007, and the 10-year Energy Plan, the latest version of which was published in 2017 (PDE 2026). Both documents predict a growth in demand and a corresponding need to expand generation capacities, which form the baseline for the government energy auction schedule. A National Energy Plan for 2050 (PNE 2050) is currently being drafted and is expected to be published in 2019.

Figure 8.1 presents the projected expansion of renewable generation capacities in the 10-year plan's reference scenario (PDE 2026).

According to the ANEEL database, there are currently 464 renewable energy projects (other than large hydropower) in the pipeline for development in the ACR and the ACL. Their combined capacity totals 9.3 GW, 75 per cent (or 6.92 GW) of which is expected to be installed by 2023.[29] The following figure shows the ANEEL projects currently in the pipeline, and incorporates the agency's predictions concerning the likelihood of this capacity being installed on schedule.

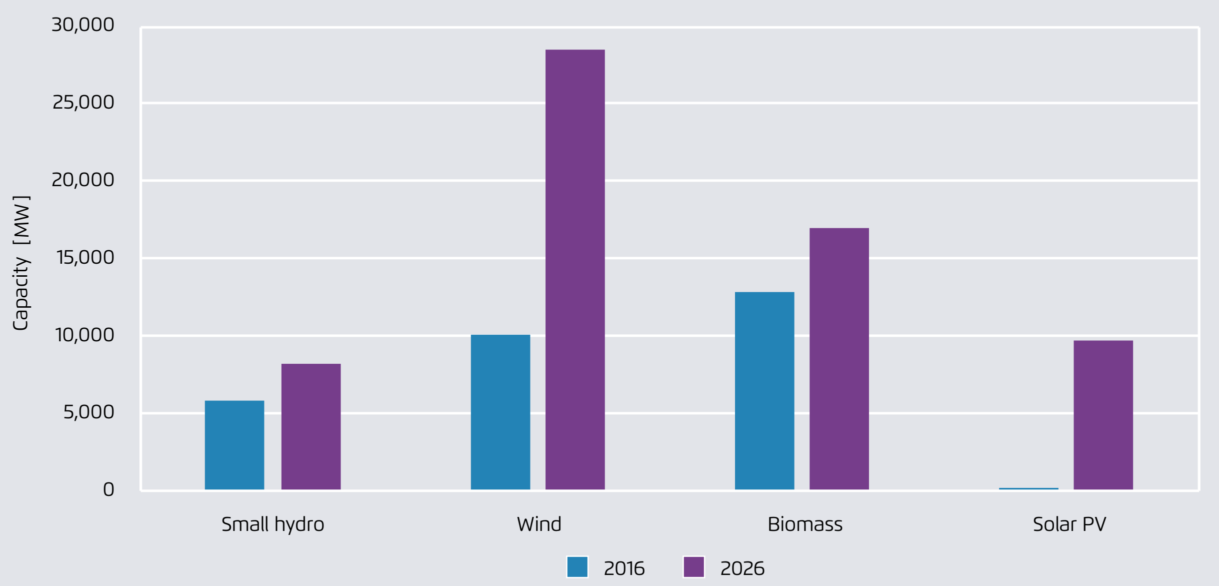
Brazilian energy policies have tended to focus on security of supply and cost efficiency, while offering subsidies for low income households (via the social tariff) and for (fossil fuel) generation, in order to redistribute the extremely high generation costs incurred in the remaining isolated power systems in the remote and mainly northern areas of the country.

In 2002, the first significant subsidy to promote alternative renewable energy sources was introduced in the form of the government's Programme of Incentives for Alternative Energy Sources (PROINFA). The aim of the programme was to diversify Brazil's power mix by increasing the proportion of energy generated via renewable sources. PROINFA has awarded 20-year PPAs to a total of 144 biomass, wind, and small hydropower projects with a combined capacity of 3.3 GW. These PPAs include a stipulated feed-in tariff for each technology and an additional subsidy scheme for investments via special BNDES financing mechanisms. The PROINFA projects were required to incorporate at least 60 per cent local content[30] in order to stimulate the national industry. PROINFA power plants were scheduled to begin commercial operations by the end

29 The ANEEL's "General Summary on Generation" details the generation projects that have already obtained all of the necessary authorisations. The ANEEL publishes an updated version of this report every month, which distinguishes between three levels of likelihood of the projects becoming operational, according to the regulator's own evaluation.

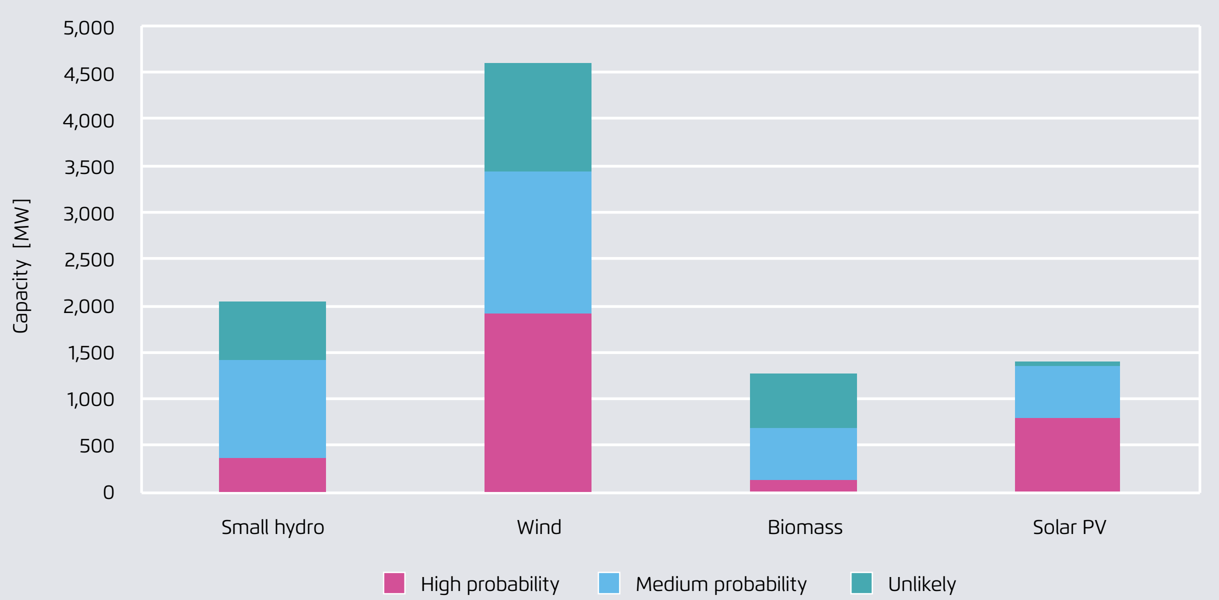
30 In order to obtain financing by BNDES, there are rules regarding a minimum participation of the Brazilian industry in the production of certain goods and services.

Installed and expected generation capacity by source (2016 and 2026) Figure 8.1



Authors' own illustration, based on EPE (2017c)

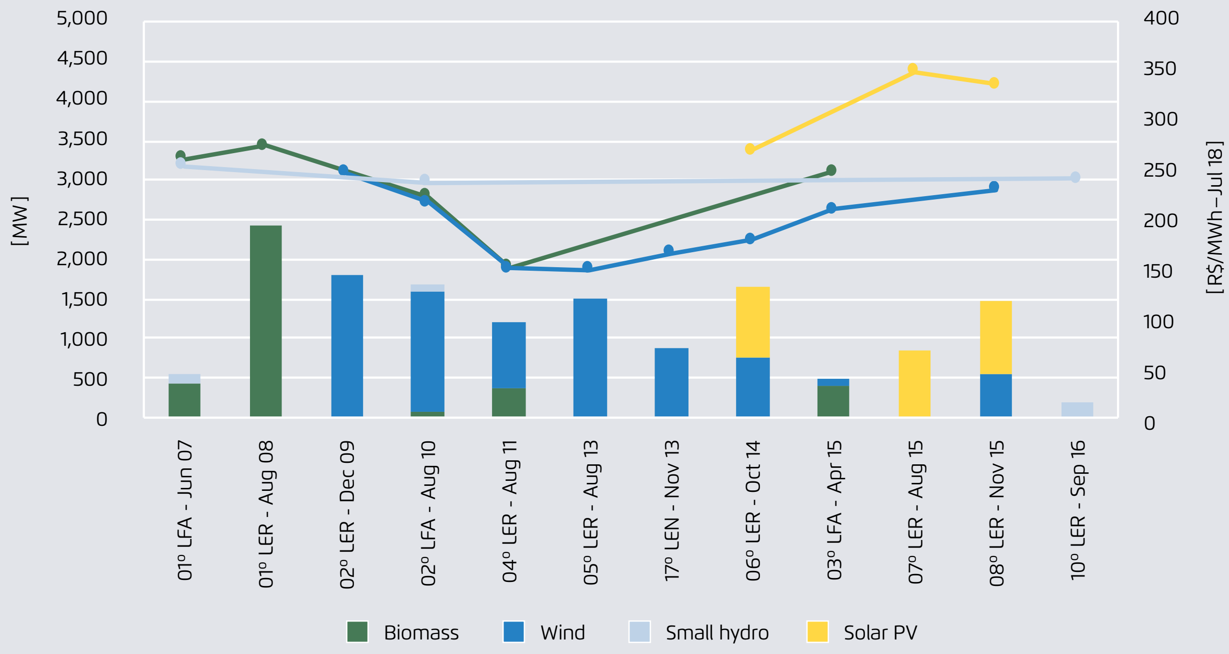
Planned renewable generation capacity up to 2023 by source and likelihood of scheduled implementation Figure 8.2



ANEEL (2018b)

Installed capacity and average prices in specific auctions for renewable sources

Figure 8.3



Authors' own illustration, based on data from the CCEE (2018b)

of 2008. The additional costs of the PROINFA premium feed-in tariffs are distributed among all consumers in the SIN (see section 5.2.1). The average generation cost of PROINFA power plants is estimated to be 309 R$/MWh,[31] while the overall cost of the PROINFA programme will total 3.2 billion Reais in 2018.

Since 2007, the government has used auctions to increase the share of alternative renewables in the power mix. To date, projects totalling more than 14.7 GW have been awarded long-term PPAs via renewable energy auctions – either via reserve energy auctions (LER), where the government decides which technologies and volumes should be contracted to the system, specific renewable energy auctions (LFA) or regular new energy auctions (LEN), which can also be exclusive for specific technologies (see section 5.1.1). Figure 8.3 shows the results for renewable sources in the above mentioned auction types from 2007 to 2017.

Some renewable energy sources are already able to compete with conventional energy sources in general new energy auctions. Wind power first became part of the Brazilian electricity mix in 2006, as a result of the PROINFA scheme, and the first wind-specific energy auction was held in 2009 (see Figure 8.1). Today, wind represents the cheapest energy source in the ACR, and competes with other energy sources at prices as low as 70 R$ per MWh (see Figure 5.2).

Biomass also makes a significant contribution to the Brazilian electricity mix (8.4 per cent in 2017, or 14.6 GW of installed capacity). Most biomass electricity generation stems from the sugar and ethanol industry, which produces electricity from sugarcane bagasse at competitive prices.

31 https://www.canalenergia.com.br/noticias/53046140/cotas-do-proinfa-vao-custar-r-3484-bilhoes-em-2018

Electricity from centralised solar PV was first enabled to participate in the ACR auctions in 2013. Although the government has conducted several renewable energy auctions since then, and has continued to incentivise PV, the technology still only accounted for 0.6 per cent of installed capacity in 2017.

Brazil also offers a 50 per cent discount on transmission and distribution fees for renewable energy facilities up to 300 MW and small hydropower facilities up to 30 MW. Furthermore, the commercialisation of strictly renewable energy sources is incentivised in the ACL, since special consumers (with < 500 kW of demand) can purchase their electricity directly from these sources rather than from their local distribution company (see section 5.1.1).

Electricity generation projects are generally granted PIS and COFINS tax exemptions through the Special Incentive for the Development of Infrastructure (REIDI). Sales of wind and solar PV generation equipment are also exempt from ICMS taxes until 2028.[32]

Centralised generation projects from energy auctions in the ACR are given access to long-term financing from the National Development Bank (BNDES) as long as they comply with local content requirements, which solar PV facilities have often struggled to meet in the past. To date, there are 7 national and international companies assembling PV modules in the domestic market, most of which are located in the industrial area near São Paulo. Canadian Solar inaugurated the first solar panel manufacturing facility in Brazil at the end of 2016, with BYD following in 2017.

8.2 Distributed Renewable Electricity Generation

In 2012, the ANEEL passed Resolution 482, which established the Brazilian Net Metering Scheme for small renewable energy projects and cogeneration – a scheme that is increasingly important for solar PV. Net metering was initially limited to plants up to 1 MW in size. In 2015 this limit was extended to 3 MW for hydropower facilities and 5 MW for all other eligible energy sources. New modalities, such as shared generation, remote generation, and compensation using multiple consumption units were also incorporated into the 2015 revision (Resolution 687). In May 2018, ANEEL initiated a public consultation process to collect input for the next round of revisions to the net metering scheme.[33] The latest version of the Resolution is expected to be published at the end of 2019 and will introduce changes related to the economic dimensions of the net metering scheme (see section 11). A lack of financing and the ICMS federal state tax on electricity injected into the grid have been perceived as the main barriers in the market. Since May 2018, DG up to 1 MW has been exempt from ICMS charges in all of Brazil's 27 states.[34]

Despite having been introduced in 2012, the incentive scheme only began to show results in 2016. A significant increase in end consumer electricity prices from 2015 on, along with a decrease in the cost of PV equipment and improvements in the associated regulatory scheme helped to improve PV's economic feasibility. Uptake of residential and commercial DG using PV is expected to increase significantly in the coming years, with installed capacity predicted to be 3.2 GW in 2024 (compared with 30 MW in 2016).[35]

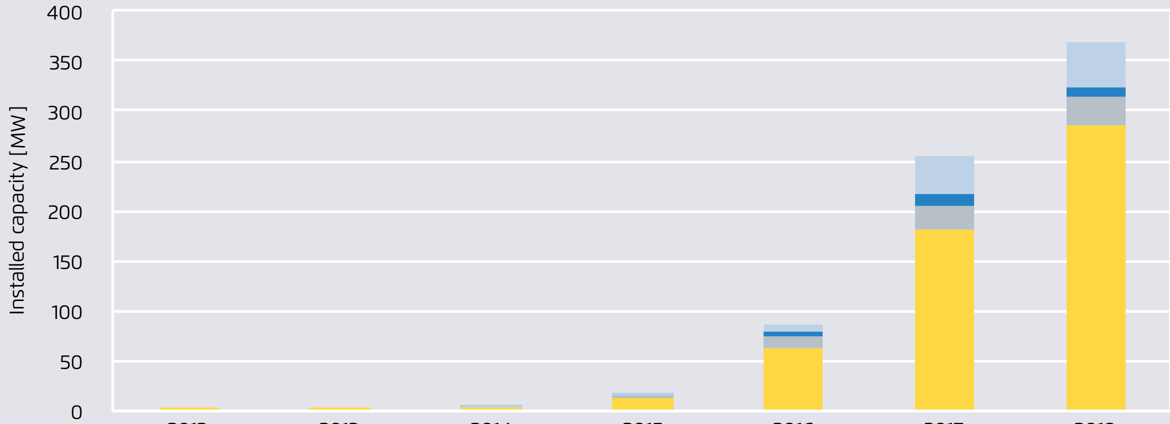
32 ICMS exemptions granted through the CONFAZ 101/97 agreement and its additions.

33 ANEEL (2018f)

34 As early as 2015, the CONFAZ had recommended that DG units up to 1 MW (which was the former capacity limit for DG) should be exempted. Some states adopted the recommendation early, while others only decided to implement the tax exemption in 2018. In the meantime, the capacity limit for DG has been raised to 3 MW or 5 MW, depending on the source, but high ICMS charges for DG electricity injected into the grid have hindered the establishment of units >1MW.

35 ANEEL (2017c)

Installed distributed generation capacity by source (2012–2018) Figure 8.4



	2012	2013	2014	2015	2016	2017	2018
Small hydro	0.0	0.0	0.8	0.8	5.5	39.8	43.5
Wind	0.0	0.0	0.1	0.1	5.2	10.3	10.3
Thermal	0.0	0.0	0.1	2.2	12.5	23.8	29.7
Solar PV	0.4	1.8	4.2	13.8	62.0	181.9	284.5
TOTAL (MW)	0.4	1.8	5.2	16.9	85.2	255.8	368.0

ABSOLAR (2018)

9 Energy Efficiency

While the energy intensity of industrialised countries and major developing countries such as China and India has been decreasing in recent years, Brazil's energy intensity, measured in primary energy consumption per unit of GDP, continues to increase by almost 2 per cent per year.

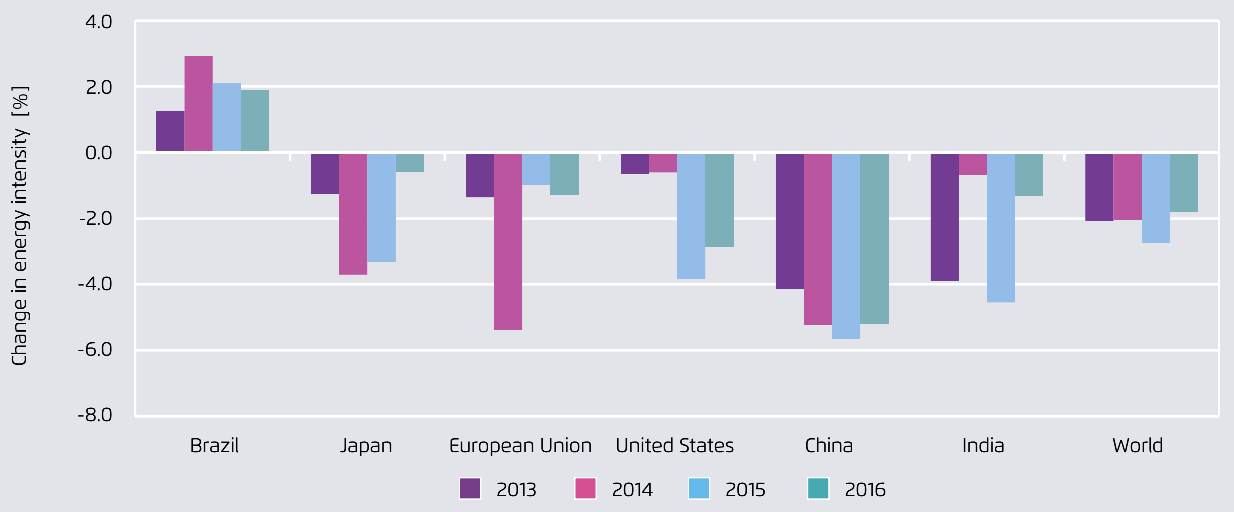
Figure 9.1 shows the changes in the primary energy intensity of a number of countries from 2013 to 2016.

By 2030, Brazil aims to increase the energy efficiency of the country's overall electricity consumption by 10 per cent compared to the business as usual scenario, as set out in the 2007 National Energy Plan for 2030 (PNE 2030) and the 2011 National Energy Efficiency Plan (PNEF). The 10 per cent efficiency target for 2030 was also incorporated into Brazil's 2016 NDCs (as an indicative target). Figure 9.3 shows the MME's predictions for future electricity demand, along with the reductions target for the period from 2010 to 2030.

Half of the planned efficiency-based reductions to national electricity consumption (which should total 106 TWh by 2030) are expected to result from market-induced improvements, while the other half are to be achieved via existing government efficiency programmes and incentives. Considering the huge potential for energy savings in all sectors of the economy, the country's 10 per cent energy efficiency targets would appear rather cautious. In the scope of the current economic crisis, electricity demand has developed below prior expectations. The latest EPE forecast predicts that energy consumption in 2026 will be 654 TWh (which is almost 25 per cent less than expected), the national energy efficiency target has not been updated since its first publication in 2007. In the latest international ranking, Brazil scored 7 out of 25 points for its national energy efficiency efforts, putting it in 20th place out of a list of 25 countries.[36]

36 ACEEE (2018)

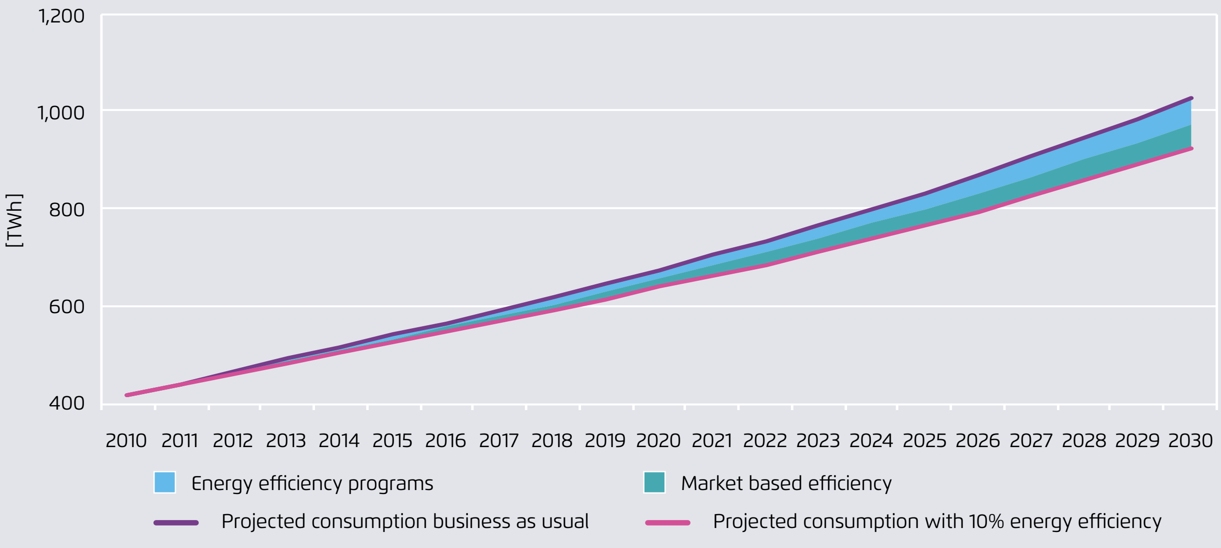
Changes in primary energy intensity in selected countries and regions — Figure 9.1



IEA (2017)

Brazil's energy efficiency target for 2030

Figure 9.2



MME (2011)

Brazil's institutional energy efficiency framework is relatively complex and involves a large number of ministries, government institutions, and other actors. The following figure shows how these different government institutions are linked to the various energy efficiency initiatives and programmes.

The legal framework for energy efficiency in Brazil is based on 2001's Law 10.295, also known as the Energy Efficiency Law. The main objective of this law is to provide a legal basis for the Minimum Energy Performance Standards (MEPS) for equipment and buildings. In 2001, the Management Committee for the Energy Efficiency Indicators (CGIEE) was created to implement and regulate the Energy Efficiency Law. From its inception, the CGIEE has established MEPS for a diverse range of facilities, though a large number of facilities have not yet been addressed and some MEPS have already become obsolete before having any significant effect due to the pace of technological change. Studies indicate that the 10 per cent energy efficiency target can only be achieved if the government significantly raises its MEPSs.

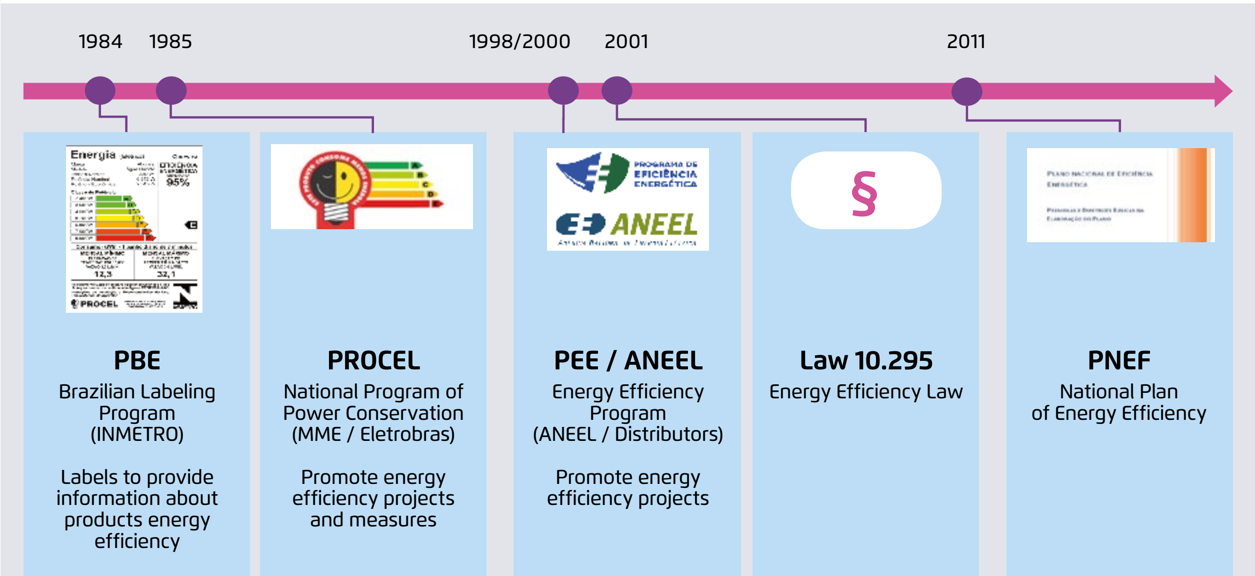
In addition to the MEP scheme, a number of other energy efficiency policies have been implemented by the government in the last three decades.

To date, the National Programme for Power Conservation (PROCEL) can be considered the most important government initiative on energy efficiency. PROCEL, which is administered by the public company Eletrobras, is responsible for promoting energy efficiency measures across the main sectors of Brazil's economy. The programme's official "Selo Procel" label is used to indicate the energy efficiency of a wide range of products, in order to help consumers choose the most efficient equipment. As part of Selo Procel, progressive targets have been set to increase the energy efficiency levels of certain product categories.

Figure 9.3 shows a timeline of the most significant government energy efficiency programmes to date.

The National Energy Efficiency Programme (PEE) was created in 1998 and legally established in 2000.

The main electricity sector-related energy efficiency policies and programmes in Brazil   Figure 9.3



Authors' own illustration

Managed by the ANEEL, the programme requires distribution companies to invest a percentage of their annual net revenues in energy efficiency projects.[37] Since 2015, distribution companies have selected the beneficiaries and the projects developed by eligible Energy Service Companies (ESCOs) by means of public calls for projects. The PEE can be considered the main source of financial incentives and funding for energy efficiency projects. In 2017, the volume of resources invested under the aegis of the PEE totalled 534 million Reais.

Table 9.1 shows the impact of the PEE since 1998.

Although the above government programmes and incentives have had some positive impact, many

37 At present, distribution companies are required to invest 0.5 per cent of their annual net revenues in energy efficiency. 20 per cent of these resources are transferred to PROCEL, while the remaining 0.4 per cent are allocated to the PEE. In 2023, this figure will be reduced to 0.25 per cent.

Impact of the National Energy Efficiency Programme (PEE) from 1998 to 2017   Table 9.1

Period	Number of projects	Reduced peak load demand in GW	Energy savings in GWh per year	Investment in billion Reais
1998–2007	3,219	1.69	5,599	1.94
2008–2017	926	0.58	1,881	1.88
Total	**4,145**	**2.27**	**7,480**	**3.81**

ANEEL (2017a)

challenges still need to be overcome in order to improve the Brazilian economy's energy efficiency. The government institutions concerned are increasingly coming to consider energy efficiency as a cost effective mean of expanding Brazil's energy sector and new approaches are regularly being considered and tested. The EPE and the ANEEL also recently began to study the economic mechanisms required to create a market for energy efficiency.

In May 2018, the ANEEL initiated a public consultation on the introduction of Energy Efficiency Auctions under the authority of the PEE (CP 7/2018). On the initial proposal, the ANEEL would set annual reductions targets for consumption and companies would then compete for a percentage of that figure on the basis of the lowest price principle. The auction winners would be regulated as "consumption reducing agents" (ARC). The programme is currently being tested via a pilot project in Roraima.

10 Grid Infrastructure and Reliability

10.1 Generation Adequacy

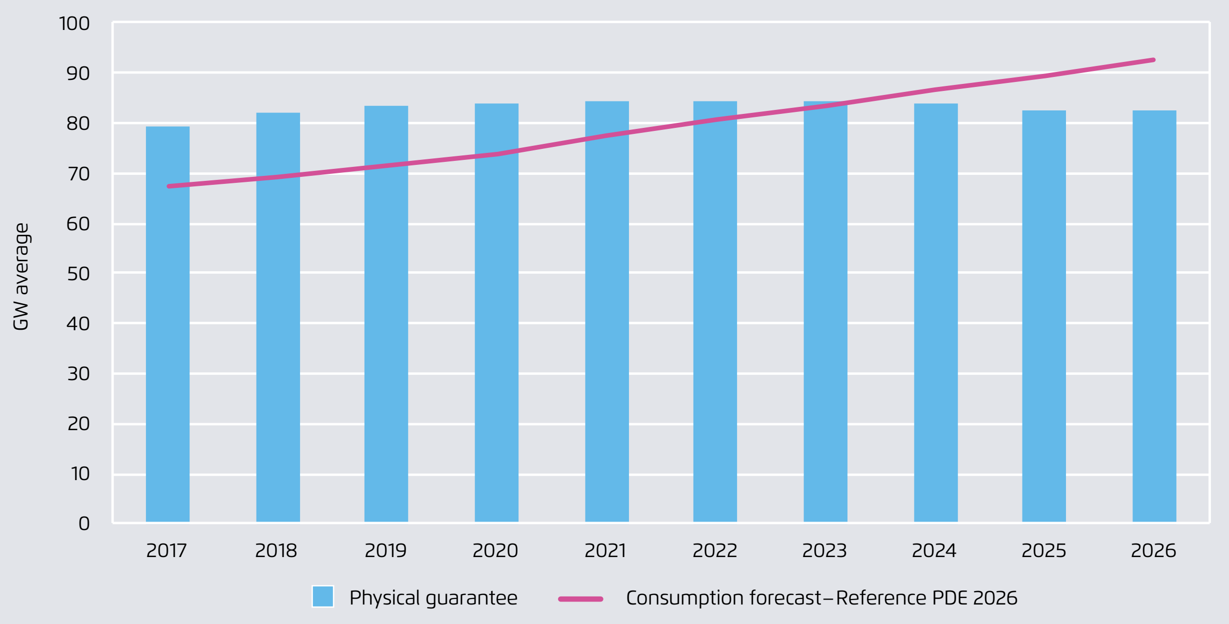
As described in section 2.1, the current design of the Brazilian electricity system was implemented in 2004 to rectify the misleading market signals on the expansion of energy-generation capacities that led to a severe energy crisis in 2001-2002. In order to ensure an appropriate level of investment in generation and thus ensure adequate supply, the new model adopted two important rules: 1) it is necessary to contract 100 per cent of forecasted demand and 2) a physical guarantee is required for every energy contract in the ACR.

The government is responsible for coordinating the expansion of ACR generation capacity. Auctions for new capacity are scheduled on the basis of the official EPE demand forecasts published in the 10 year energy plan (PDE) and updated every 2 years. The hydrological risks of the hydro-thermal electricity system are reflected in high generation costs rather than in an actual scarcity of energy in times of drought.

As a result of the economic recession, electricity consumption has remained below expectations in recent years (see Figure 10.1). Since new generation capacities have been contracted on the basis of the previous, higher expectations, there is currently a capacity surplus, which is expected to last until at least 2023.

Transmission capacities, which have long represented a bottleneck in the Brazilian electricity sector, are currently being increased via government auctions at conditions that have resulted into a strong interest and competition of multiple investors.

Physical guarantee and consumption forecasts in the PDE 2026 reference scenario — Figure 10.1



EPE (2017b)

10.2 Quality indicators for electricity distribution

Grid reliability of the distribution system is measured by means of two continuity indicators in Brazil: duration of interruption per consumer (DEC) and frequency of interruption per consumer (FEC). These represent, respectively, the sum of all interruptions per consumer unit (in hours) and the number of service interruptions per consumer unit in a given period of time. The FEC figures make it possible to assess the quality of existing installations and maintenance levels, while the DEC indicates whether the availability and quality of technical service provision is sufficient.

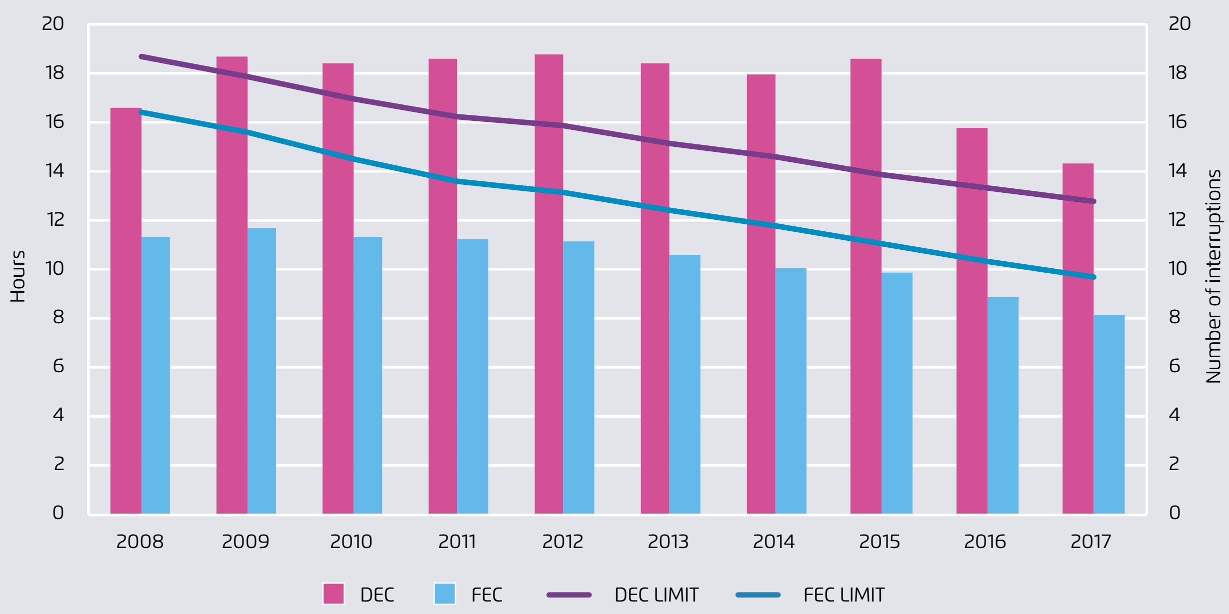
The ANEEL sets upper limits for these indicators and claims that performance among distributors has improved after individual targets were established for each distribution company. These targets were set using the relevant Distribution Procedures (PRODIST), which seek to standardise the technical procedures involved in the operation and performance of electricity distribution systems.

Figure 10.2 shows the DEC and FEC limits from 2008 to 2017 and the annual average performance of all distributors, according to ANEEL.

10.3 Smart Metering

Brazil currently has no policies for smart grids or smart meters and the associated technology is still in its infancy in the country. There are currently two situations in which smart meters would be installed in Brazil: 1) where eligible end consumers opt for the white electricity tariff (see section 5.2.1) and 2) where end consumers opt for electronic pre-payment or post-payment schemes (see section 11).

DEC and FEC continuity indicators (2008–2017) — Figure 10.2



ANEEL (2018e)

ANEEL's Normative Resolution RN 502/2012 regulates the deployment of smart meters for white tariff end consumers in the low voltage grid (type B consumers).[38] The resolution allows for the use of two types of meters with different functions. The first type is suitable for consumers who choose to migrate to the white tariff and allows their consumption in at least four different price periods to be measured and displayed. This type of meter has to be provided to the consumer by the distribution company without charge. The second type of meter, which offers additional features but is more expensive, can also be requested by consumers opting for the white tariff, though they have to pay the price difference themselves. Consumers who choose a smart meter without opting for the white tariff have to cover the full cost of the meter.

Normative Resolution RN 610/2014 regulates electronic electricity pre-payment and post-payment using smart metering. Where the distribution company offers a pre-payment option to its customers or decides to use electronic metering, it has to install a smart meter and cover the associated costs. The regulation is currently being revised (see section 11).

Suppliers of smart meters have full responsible for handling the associated data and are required to comply with consumer rights concerning data protection in accordance with the Federal Constitution. ANEEL also regulates the use of the distribution grid for communication purposes, which allows suppliers to transmit real-time data and to control services remotely via smart meters (RN 375/2009).

To date, smart metering remains limited to several pilot projects in the main concession areas and one project that aims to combat energy theft in the state of Rio de Janeiro.[39] The distribution company Copel has recently announced its plans to install up to 120,000 devices in the city of Sao José dos Pinhais in the state of Paraná. At present, Copel is also installing 5,000 smart meters in the town of Ipiranga, also in Paraná state, which will be the first Brazilian town with 100 per cent smart meter coverage.[40]

38 Residential, commercial, industrial, and rural areas connected to the low-voltage grid.

39 Ampla (2009)

40 Copel (2018)

11 Recent Policy Developments

11.1 General Power Sector Reform

Efforts are currently being made to introduce sweeping reforms to the Brazilian electricity sector. Following the CP 33 public consultation in July 2017, the government drafted a reform proposal that was presented in February 2018.

On the basis of the CP 33 consultation, the proposal elaborates a number of wide-ranging reforms to the commercial and technical structure of the electricity sector, including:

- The implementation of a binomial electricity tariff for a range of electricity consumers, which would lead to radical changes in distributors' business models in the residential consumer segment. This reform would transform distribution companies from electricity retailers into grid connection providers.
- The expansion of the ACL to all electricity consumers in the same timeframe (i.e. by 2028) in order to enable consumers to freely choose their electricity supplier from a list of electricity retailers and other sectoral agents. Distribution companies will be responsible for supplying all customers that choose to stay in the ACR.
- The separation of products in the ACR by pricing energy, capacity, reliability, social and environmental attributes, and flexibility separately. On this proposal, buyers such as distribution companies and retailers would buy and offer their product mix according to consumer demand.

It has not proved possible to approve the proposal before the elections of October 2018. The responsible member of the Chamber of Deputies, Fábio Garcia, therefore aims to incorporate the legislative proposal into another legal proposal concerning the portability of electricity bills (PL 1917/2015), which is due to be put forward in 2019. PL 1917/2015 aims to change the electricity sector's commercial model by allowing all end consumers to choose their electricity provider by 2028, and will include elements of the initiatives discussed above. The long delays to the approval process allowed several interest groups to increase political pressure on the government and ensure that alterations were made to the initial proposal, which was once considered to enjoy sector-wide consent. Civil society participation in the discussion process nonetheless remained limited.

11.2 The ANEEL's Regulatory Agenda 2018/2019

In addition to the broad sectoral reforms initiated in response to CP33, the ANEEL is also at work on implementing its regulatory agenda, which has been published bi-annually since 2015. The agenda aims to offer market players a transparent overview of the expected changes to market rules, while allowing all relevant stakeholders to participate in related forums and discussions.

The regulatory agenda for 2018/2019 lists 77 projects in total, including 23 projects that involve public consultations and 53 projects that are to be discussed in public hearings. The following issues are of particular importance with regard to renewable energies, energy efficiency, and the decarbonisation of the Brazilian economy:[41]

Revision of RN 482/2012 – Revision of the Brazilian Net Metering Scheme:
Brazil implemented a net metering scheme in 2012, which was set out in RN 482/2012 and expanded in RN 687/2015 to include several new modalities (see

41 The ANEEL's full regulatory agenda can be accessed in Portuguese at: http://www.aneel.gov.br/agenda-regulatoria-aneel

section 8). In the wake of the 2015 modifications, the market grew significantly. The number of DG units stayed below initial forecasts, while the installed capacity surpassed the EPE's forecasts in 2017, totalling 254 MW rather than the predicted 102 MW.

The current round of revisions to the regulation, which was provided for as part of RN 687/2015, began with the publication of a technical report by ANEEL in May 2018, followed by a public consultation that ran from May to July 2018 (CP 10/2018). The process also includes two public stakeholder hearings in 2018 and 2019, which are intended to gather input on the ANEEL's regulatory impact report (AIR) and on the preliminary version of the revised regulation. The major changes to the regulation will focus on the allocation of costs, since the current rules are considered to include hidden subsidies that are amortised both by consumers that make no use of DG and by distribution companies. ANEEL is analysing 6 possible ways of providing financial compensation for distributed electricity generation. This will involve separating net metering discounts into several tariff components in order to account for the these items in a more nuanced manner. Depending on which model is adopted, more than 60 per cent of the current discounts on injected electricity may be abated.[42] ANEEL is currently considering whether to implement the new rules gradually in order to assure the further growth of the market.

The revised regulation may also include measures to:

- simplify billing procedures
- improve grid connection rules
- change the limits for installed capacities, which may involve reductions
- alter the eligibility of energy sources within the net metering scheme
- redefine the multiple-user modalities introduced in 2015
- introduce financial contributions for the use of the distribution grid

The new rules are expected to be published by the end of 2019. Existing GD units will be protected and will only be bound by the rules in place at the date they were connected to the grid. The installation of additional capacity is therefore expected to peak during the second semester of 2019. The revision process for RN 482/2012 can be followed on the ANEEL website.[43]

Regulatory Framework for Hybrid Power Plants

Current power sector regulation does not allow for combined generation facilities, such as hybrid power plants. This issue has been examined by the EPE in order to identify the potential benefits of combining different energy sources, and the existing regulatory barriers to doing so. The EPE issued a technical report on the topic in June 2018.[44] It had previously published a technical report on linking PV and wind power plants in 2017.[45]

The ANEEL included the topic in its regulatory agenda and scheduled a public consultation process on the issue for the second half of 2018. The regulatory dimensions that it may address include:

- the definition of hybrid power plants
- rules for sharing the grid capacity system and capacity usage rights

42 https://www.canalenergia.com.br/artigos/53063557/a-aneel-instaura-consulta-publica-para-aprimorar-as-regras-aplicaveis-a-micro-e-minigeracao-distribuida

43 ANEEL (2018g)

44 http://www.epe.gov.br/pt/imprensa/noticias/usinas-hibridas-epe-publica-analise-qualitativa-de-temas-regulatorios-e-comerciais

45 http://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-232/topico-214/Metodologia%20para%20avalia%C3%A7%C3%A3o%20de%20usinas%20h%C3%ADbridas%20e%C3%B3lico-fotovoltaicas.pdf

- curtailment rules for parallel electricity generation
- rules for combining already existing plants with new power plants
- energy procurement and compensation mechanisms
- accounting and clearing mechanisms for generated electricity

Further discussions and public consultations on these topics are forseen. In addition, a legislative proposal in the Senate (PLS 107/2017) aims to allow hybrid power plants to be admitted to public energy auctions in the ACR and is awaiting approval by the commission on infrastructure services.[46]

Binomial Electricity Tariff

The implementation of a binomial electricity tariff for all consumers is one of the central elements of the proposed sectoral reform. The ANEEL´s position is that the necessary changes should be made within the regulatory framework rather than via legislative proposals, in order to simplify the procedure for future adjustments. The ANEEL has included the issue in its regulatory agenda and aims to publish a final proposal on the regulation by the end of 2019. Thus far, the regulator has not adopted a final position on whether the new rules should come into force in 2020 or at any later point in time. The binomial tariff has been the subject of heated debate, with distribution companies and the PV industry locking horns over the matter, since the implementation of the tariff and the associated net metering may significantly disadvantage solar PV generators in comparison with the present rules. Distribution companies, meanwhile, have complained about hidden subsidies for consumers that use DG. A public consultation on the issue was held from March to May 2018. The relevant documents can be accessed in Portuguese on the ANEEL website.[47] The issue will also be treated during the revision of the current net metering scheme, as described above.

Revision of the rules for electricity pre-payment

In 2014, the ANEEL introduced a regulation enabling pre-payment for electricity consumption (RN 610/2014, ANEEL). The motivation for the new regulation was to reduce the commercial losses caused by payment default and energy theft, which in 2015 totalled 15 TWh or 8 Billion Reais[48]. The regulation specified that companies choosing to allow pre-payment in parts of their concession area would have to expand the scheme to the whole area within the following three years. The decision to opt for pre-payment for electricity is made by the customer, whereas the distribution company has to provide the necessary metering hardware. Once the consumer uses up the credit he has charged to his account, the electricity supply can be automatically cut off. Within the conventional billing system, by contrast, customers are notified at least 15 days before the supply is cut off. Consumers that fall behind on their electricity payments are charged penalties of up to 2 per cent plus inflation and an interest rate of 12 per cent per year. On the pre-payment plan, customers are faced with no such additional costs. A broad consultation process is currently underway to collect input on a revised version of the regulation, which is expected to be published in 2019. To date, none of the 63 distribution companies have decided to offer the service to their customers, citing unsatisfactory regulation.[49] Consumer institutions, meanwhile, have strongly

46 https://www25.senado.leg.br/web/atividade/materias/-/materia/128825

47 http://www.aneel.gov.br/consultas-publicas?p_auth=EsLTzTxs&p_p_id=consultaspublicasvisualizacao_WAR_AudienciasConsultasPortletportlet&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_count=1&_consultaspublicasvisualizacao_WAR_AudienciasConsultasPortletportlet_consultaId=321&_consultaspublicasvisualizacao_WAR_AudienciasConsultasPortletportlet_javax.portlet.action=visualizarConsulta

48 Acende (2017)

49 http://www2.aneel.gov.br/aplicacoes/consulta_publica/documentos/Nota%20T%C3%A9cnica%200121_2017-SRD-ANEEL.PDF

criticised the scheme, since it undermines the provision of basic services.

Regulating financial compensation for "constrained off" wind and solar hydropower plants
In the ACL, regulatory gaps have been identified in relation to the constraints placed on wind, solar, and hydropower plants to maintain the operational security of the SIN. The ANEEL is looking to address these lacunae by establishing a financial compensation mechanism that responds to the concerns of the industry. The regulation is expected to be published by the end of 2019.

Defining rules concerning electric vehicle charging:
In June 2018, the ANEEL published a set of rules concerning electric vehicle charging. The new regulatory framework is set out in RN 819/2018, which was elaborated over several months and included a public consultation process. RN 819/2018 defines electric vehicle charging as a service provision in a free market, in which prices can be negotiated between service providers and users. It opens up the sale of electricity to end consumers, which was traditionally limited to distribution concessionaires, to any interested market player and thereby creates new business opportunities. Companies that are active in the nascent Brazilian electric vehicle market welcomed the ANEEL's decision and its expected positive impact on market growth. Alongside distribution companies and electricity retailers, gas stations, parking service providers, shopping centres, supermarkets, and other commercial retailers can now begin to offer paid charging services. The lack of charging infrastructure can be considered one of the main barriers to the growth of the electric vehicle sector in Brazil.

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Agora Energiewende develops scientifically based and politically feasible approaches for ensuring the success of the Energy Transition. We see ourselves as a think-tank and policy laboratory, centered around dialogue with energy policy stakeholders. Together with participants from public policy, civil society, business and academia, we develop a common understanding of the Energiewende, its challenges and courses of action. This we accomplish with a maximum of scientific expertise, oriented towards goals and solutions, and devoid of any ideological agenda.

E+ Energy Dialogues Institute
Institute E+ is an independent think tank that promotes the inclusive dialogue of stakeholders to shape Brazilian energy transition as a vector for low emissions economic growth. To support a scientifically sound and evidence-based discussion, E+ works with a multidisciplinary team and partners to provide knowledge and studies about technological, social and economic solutions for an effective and efficient energy transition. With its work, E+ promotes pragmatic solutions with a sustained impact that build on the synergies of different sectors for the development of sound and integrated solutions for the Brazilian society.

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