Chile country report

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

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Acronyms and abbreviations

BNIS	Big North Interconnected System
CCGT	Combined cycle gas turbine
CIS	Central Interconnected System
COD	Commercial operation date
CPI	Consumer price index
DPTS	Development Pole Transmission System
DTS	Dedicated transmission system
LCOE	Levelised cost of electricity
LYOC	Last year of contract
NCRE	Non-conventional renewable energy
NEC	National Energy Commission
NES	National Electric System
NTS	National transmission system
PV	Photovoltaic
RE	Renewable energy
REPO	Renewable power obligation
UF	Unidad de Fomento (unit of account that adjusts with Chile's inflation with a value of US$40.9/UF on 31 December 2020 resulting from the rates CH$29,070.3/UF and CH$710.5/US$)

1. Introduction

The Chilean Electricity Act enacted in 1982 created an electricity market where power generation companies and large customers can freely negotiate energy supply contracts. The Act provides for the interconnection of all electricity companies located in the same area, and obliges transmission companies to allow open access to their networks.

The Act further provides for the coordination of electricity companies through a coordinating body –the Coordinator – to maintain security of supply and operate the system at minimum cost. Accordingly, the Coordinator dispatches plants in ascending order of operating cost until demand is covered. The fact that these dispatch orders are independent of existing supply contracts means that power generation companies need to transfer energy between one another to reconcile their contractual obligations with the dispatch orders. These reconcilations are computed by the Coordinator on an hourly basis.

In each hour, the energy surplus (deficit) of a generator equals the difference between its injections into the system, resulting from the Coordinator's mandatory dispatch orders, and its energy withdrawals to fulfil its contractual supply obligations, if any. In turn, the surplus (deficit) of capacity equals the difference between its availability to reliably supply energy at times of peak demand, the so-called sufficiency power, and the peak energy demand of its customers.[1]

The Act stipulates that these reconciliation transfers will be priced using peak-load pricing,[2] which consists of an energy charge and a capacity (power) charge. The former equals the system's short-term marginal cost of generation, while the latter is the marginal cost of capacity. The Coordinator approximates[3] the energy charge by using the operating cost of the last unit dispatched and the capacity charge by using the annuity that pays for the cheapest possible generating units capable of supplying additional power at peak hours.

The mechanism for adjusting hourly energy imbalances is not a market in itself. However, the administratively computed energy price matches what would be the equilibrium price if the market were perfectly competitive (see, for instance, Arellano & Serra, 2010). Thus, using an almost universal denomination, in what follows we will refer to it as the spot market and to the system's short-term marginal cost of energy as the spot price.

This report focuses on the energy supply contracts that distribution companies, as mandated by law, auction on behalf of their regulated customers. The Act required bidders to back up their bids with installed or planned power plants, which could be of any technology, including fossil-fuel power plants. Since the 2017 auction, the rules require bidders to show that they will have the capacity to supply the electricity offered during the first five years of the contract. In

[1] Its computation considers the statistical information from the last five years and, thus, is unrelated to its past, present or future generation. A generator's sufficiency power surplus equals the sum of the sufficiency power of its plants minus its contractual supply commitments. The formula to calculate the initial sufficiency power of a plant includes forced outage rates, maintenance, fuel availability for thermal units, water availability and storage capability in hydroelectric power plants, and plant factors in solar and wind power plants. The initial sufficiency power for a solar or wind power plant corresponds to the minimum between its lowest annual capacity factor and the simple average of its capacity factor for each of the 52 hours with the highest. The consumption of the customers corresponds to the actual measurements.

[2] It corresponds to the pricing at the marginal cost of a non-storable product (Boiteux, 1960).

[3] This definition of instant marginal cost ignores intertemporal constraints, such as plant ramp-up times, that affect system dispatch, and is therefore an approximation of the actual marginal cost of the system (Muñoz et al., 2021). These constraints have become more binding with the massive input of photovoltaic and wind plants.

previous auctions, the capacity backing requirement played the role more of a guarantee of contract performance.

The auctioneer – the pool of distribution companies – auctions long-term contracts (up to 20 years) at least five years before the start of supply, selecting bids that allow it to meet the energy requirements at the lowest cost. Contract awardees also receive a power payment, which equals the energy withdrawn by the distribution companies attributed to that contract during the system's peak demand hours, valued at the power price set in the contract.

Awardees are contractually obliged to purchase power on the spot market to cover any energy supply shortfalls. This exposure to the spot price represents a risk for non-dispatchable renewable energy (RE) technologies as they may have energy shortfalls in hours when the spot price is high and, conversely, energy surpluses when the spot price is low. Conventional power plants, on the other hand, are likely to be dispatched when the spot price is high, and thus do not face this spot price exposure risk.

In 2015, to reduce the risk of exposure to the spot price for variable RE, Chile's government introduced the auctioning of power supply contracts restricted to time blocks reflecting the generation profile of wind and solar photovoltaic (PV) plants. The available results point to a limited impact on overall market prices, which is to be expected considering that the time block award prices adjust according to energy supply (quantity and cost).

In the last three tenders held between 2015 and 2017, the auctioneer awarded contracts totalling 323 400 MWh (16 170 MWh per year for 20 years). These auctions saw the number of bidders grow dramatically compared to previous years, and the prices offered fell sharply. A plausible conjecture is that this change is due to the sharp drop in RE generation costs, especially for PV and wind power. All new projects backing bids during this period were RE plants and the trend of awarded prices closely followed those in successful auctions for RE energy in the rest of the world.[4]

The auctions, at least in the last three years, thus seem to have been cost-effective. This outcome is particularly significant given that bidders are exposed to spot prices, which is not necessarily the case in other countries. The auctions have also been performance-effective. All the awardees have fulfilled their financial obligations arising from their participation in the system's mechanism to settle imbalances, with a sole exception in 2010. In the coming years, when the supply period begins for those contracts awarded under more competitive conditions, the latter result could change.

[4] According to Ascencio-Vásquez, Brecl and Topič (2019), the world's best location for PV is the Atacama Desert in Chile because of the very high irradiation and the number of sun hours due to the relative proximity to the Equator, resulting in capacity factors of 35% (Cruzate, 2017). Similarly, there are strong wind, geothermal and hydropower resources across the country.

2. Country overview

Chile is located in the south of South America and borders the Pacific Ocean to the west and the Andes Mountains to the east. The country shares frontiers with Argentina, Bolivia and Peru and has approximately 19.1 million inhabitants, of whom 7.9 million live in the 'Metropolitan Region' that includes the capital, Santiago.

Politically, the country is organised as a democracy with a presidential regime and a bicameral legislature. Since the return to democracy in 1990, following the end of the military dictatorship of Augusto Pinochet, the country enjoyed remarkable political stability. Recently, however, there has been growing social unrest due to discontent with the country's unequal wealth distribution.

Economically, the country experienced high growth from 1990 to 2015, with one of the highest GDP per capita growth rates in Latin America, both in current and in purchasing power adjusted terms (Figure 1). As a result, Chile is classified as a 'high income' country by the World Bank and is a member of the Organisation for Economic Co-operation and Development (OECD). Chile also ranks 59 out of 190 countries in the World Bank's Doing Business ranking and has deep, competitive financial markets.

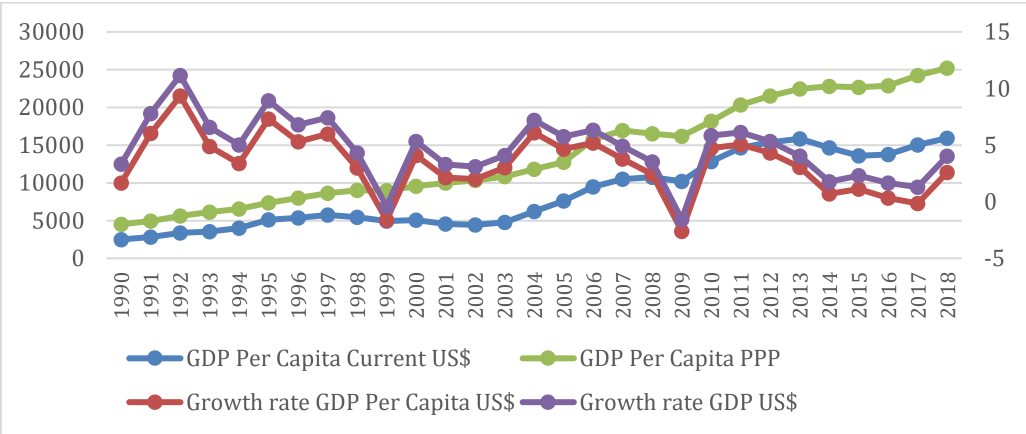

Figure 1: Chile's GDP per capita and growth rate, 1990–2018
Source: World Bank

Recently, the country's economic fortunes have declined due to the wave of protests that started in October 2019; the deterioration of its terms of trade as a result of conflicts between China and the US; and the crisis caused by the coronavirus.

Social unrest has caused uncertainty in the business environment, especially after the referendum held on 25 October 2020, in which almost 80 per cent of voters approved changing the Constitution. These events led to a significant depreciation of the Chilean peso, which dropped 19.9 per cent against the US dollar between 18 October 2019, the day the protests began, and 18 March 2020, the day the government declared a state of emergency due to the coronavirus pandemic. The fall and high volatility in the exchange rate forced the Central Bank of Chile to intervene. The local stock index (IPSA), which measures the performance of the 40 most traded stocks on the Santiago stock exchange, fell 44.4 per cent in the same period.[5]

[5] Since that date, the Chilean peso has appreciated, and the stock market index has partially recovered due to a decrease in unrest and a substantial improvement in the prices of goods exported by the country.

2.1. Chile's power sector

2.1.1. National Electric System

Chile's National Electric System (NES) links the city of Arica with the Chiloé Islands through a transmission network that extends for about 3 000 km and covers a territory where 97 per cent of Chileans live. The NES resulted from the interconnection on 1 January 2018 of two systems: the Big North Interconnected System (BNIS), with a capacity of 5 288 MW, and the Central Interconnected System (CIS), with 17 081 MW. By 2019, the NES had an installed generation capacity of over 25 GW and supplied a maximum demand of 11 GW (Table 1).[6]

Table 1: Key information on Chile's electricity sector, 2019

Technology	Installed capacity (MW)	Installed capacity (%)	Generation (GWh)	Generation (%)
Coal	4 825	19	28 372	37
Natural gas	4 840	19	14 127	18
Diesel	3 140	13	552	1
Hydro reservoir	3 355	13	9 230	12
Hydro run-of-river (> 20 MW)	2 820	11	9 729	13
Mini hydro run-of-river (< 20 MW)	516	2	1 834	2
Biomass	514	2	1 819	2
Cogeneration	18	0	130	0
Geothermal	40	0	202	0
Solar	2 886	12	6 300	8
Wind	2 136	9	4 799	6
TOTAL	**25 090**	**100**	**77 094**	**100**
Electricity access rates (%)				
Urban	100			
Rural	96.5			
Peak demand (MW)	**10 900**			

Source: Commission (http://energiaabierta.cl/blockchain/) and https://www.cne.cl/en/estadisticas/electricidad/, 2020

Figure 2 shows strong growth in installed capacity over the period 2010–2019. It also reflects a highly concentrated market, although decreasing over time. In 2019, four companies (AES Gener, Enel, Engie and Colbún), of which local investors control only one (Colbún), accounted for 78 per cent of total generation.

[6] Three reasons explain the low usage of the system's installed capacity: (i) the high (50%) participation of RE technologies with an average capacity factor of 31 per cent; (ii) the low dispatch of gas-fired plants due to the high cost of generating power with liquefied natural gas (LNG); and (iii) over-investment in backup capacity caused by a regulatory failure.

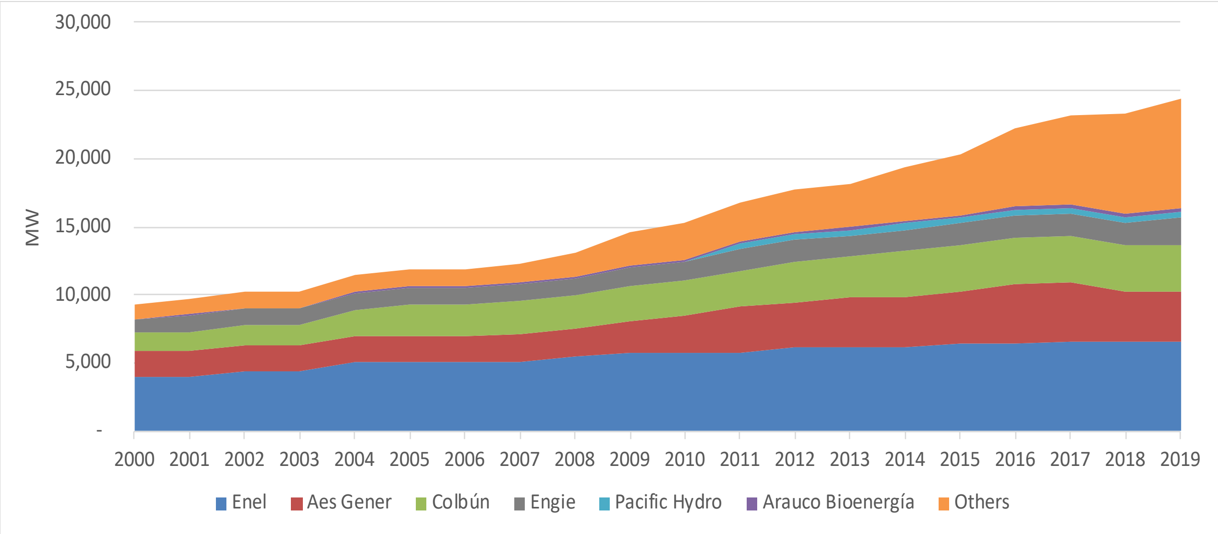

Figure 2: Installed capacity by owner, NES
Source: Authors' compilation based on Commission (http://energiaabierta.cl/blockchain/), 2020

Figure 3 shows the evolution of installed capacity by technology. Until the mid-1990s, hydropower was the dominant technology. In the CIS, it accounted for 86 per cent of total power generation in 1995. From 1998, as a result of growing opposition from environmental and indigenist groups, construction of new hydropower plants was halted, which was offset by a rapid expansion of combined cycle gas turbines (CCGTs) supplied by Argentine natural gas brought in through pipelines.

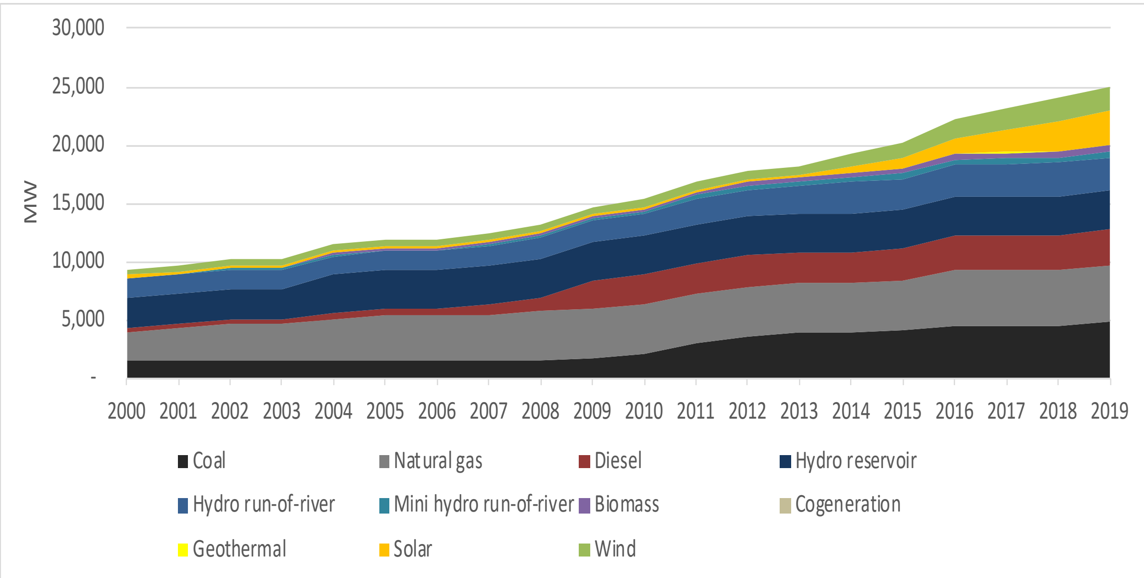

Figure 3: Installed capacity by technology, NES
Source: Authors' compilation based on Commission (http://energiaabierta.cl/blockchain/), 2020

From 2005, as a result of the restrictions and taxes that Argentina imposed on gas exports, diesel plants were built to substitute CCGTs, some of which became dual fuel plants. After the construction of gas terminals, gas-fired generation recovered somewhat, but coal-fired power plants covered the demand growth due to lower costs. In recent years, as a result of strong citizen opposition to the construction of fossil-fuel power plants and the sharp drop in solar and wind costs, the use of RE technologies has expanded rapidly (Figures 3 and 4).

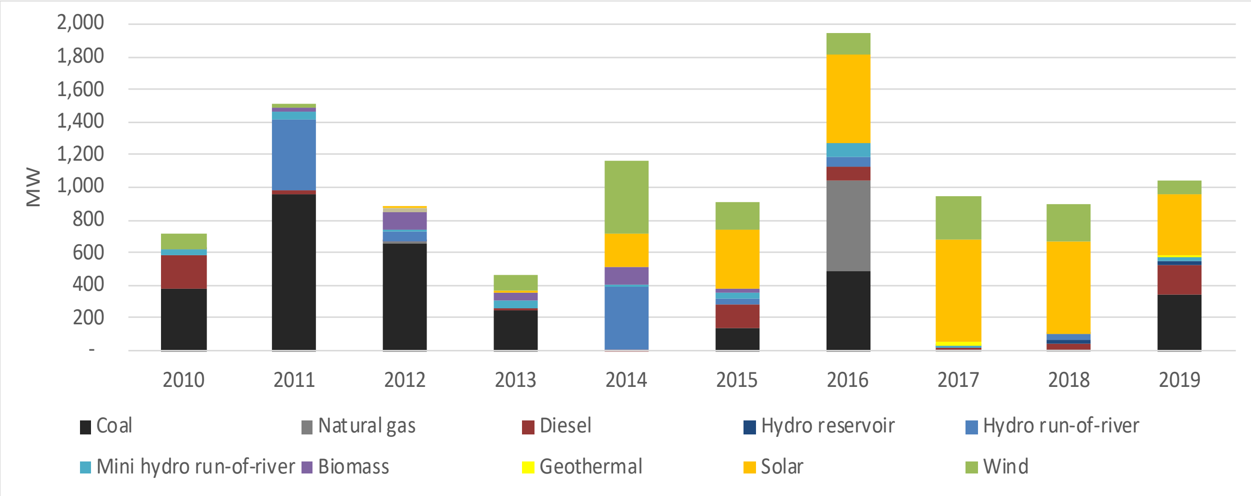

Figure 4: New installed capacity, NES

Source: Authors' compilation based on Commission (http://energiaabierta.cl/blockchain/), 2020

2.1.2. Power sector structure

The creation of the institution in charge of designing and implementing the energy markets was the first milestone in Chile's electric reform. The National Energy Commission (Commission), instituted in 1978, was made responsible for, among other functions, proposing sectoral policies and calculating regulated tariffs.[7] The Commission's primary task was the elaboration of the Electricity Act enacted in 1982, which laid the foundations for the current regulation.

The law distinguished three separate activities – the generation, transmission and distribution of electricity – although it did not initially prohibit vertical integration. It considered electricity distribution companies to be natural monopolies and thus regulated them. It also granted generators access to the transmission network, though it initially left transmission charges unregulated.

The government, along with enacting the new Act, restructured the electricity sector, creating new companies from the old state-owned companies. The two largest electricity companies (Endesa and Chilectra) were separated into seven generation companies and eight distribution companies.[8] Most of these firms were privatised between 1986 and 1989.

Since its inception, the Electricity Law has undergone numerous changes. The following is a summary of the latest version, incorporating some historical footnotes.

Generation

The Act mandates the electricity companies located in the same zone to interconnect and coordinate to maintain service security and minimise operating costs. The Coordinator dispatches plants in ascending order of operating cost until demand is covered (merit-order dispatch). Generators need to cover their contractual supply obligations by either generating sufficient power (and being dispatched), or buying power on the spot market.

[7] Previously, the sectoral policy had been mainly in the hands of Endesa, the largest state-owned electric company, which was in charge of the country's electrification plan.

[8] The subdivision also created two small, isolated, vertically integrated companies in the south of the country.

Transmission

The Act provides that: (i) the Commission is responsible for developing transmission expansion plans; (ii) the Coordinator publicly auctions the expansion projects based on the annual payments requested to build and operate the project for 20 years; (iii) the Commission computes the remuneration of facilities that exceed the 20-year period or non-auctioned old ones; and (iv) consumers finance the transmission systems in proportion to their consumption, except for dedicated transmission facilities, which are paid for by their users.[9]

Dedicated transmission systems (DTSs) are those systems built primarily to supply energy to unregulated users or to evacuate it from generating plants. The Act distinguishes a particular type of dedicated system: the Development Pole Transmission System (DPTS). The DPTSs serve to evacuate energy from areas classified by the Ministry of Energy as a generation development pole, where the latter is a territorially identifiable area with RE resources, whose exploitation using a single transmission system is in the public interest.

Finally, the Act also limits the ownership stakes of generators or distributors in transmission companies to 8 per cent individually and 40 per cent when combined, and excludes owners of transmission facilities from participating in generation or distribution.

Distribution

Regulated customers – those with a maximum demand below 0.5 MW or with a maximum demand between 0.5 and 5 MW who choose to be regulated – purchase electricity from distribution companies.[10] They pay a tariff composed of the average price at which distribution companies purchase electricity from generators, the transmission cost and the distribution cost.[11] The latter is set through a regulated process so that an efficient company achieves a given rate of return on its assets. This rate is calculated using the CAPM[12] method but is limited to a range between 6 per cent and 8 per cent.[13] Distribution companies purchase energy (and power) on behalf of their regulated customers through the auctioning of long-term procurement contracts analysed in section 3.

Table 2: Key institutions in Chile's electricity sector

The Ministry of Energy	Created in 2010, it is responsible for preparing and coordinating plans, policies and regulations for the proper functioning and development of the sector, ensuring compliance with them. Every five years it carries out a prospective study of the electricity sector called the energy planning process. In case of need, it implements up to two public auctions a year to cover the part of the obligation for 20 per cent of the energy withdrawn by the generators to be **non-conventional renewable energy (**NCRE**)**.

[9] Initially, transmission service providers and generators directly negotiated the transmission tolls. In 1990, a law amendment set up a mandatory binding arbitration process if parties did not reach an agreement. The legal change of 2004 introduced the regulation of transmission, establishing that consumers would pay 20 per cent of its costs. The actual regulation dates from 2016.

[10] Until 2004, regulated customers were those with a maximum demand of less than or equal to 2 MW.

[11] It also includes a charge for the financing of both the Coordinator and the Energy Expert Panel.

[12] The capital asset pricing method is used to express the relationship between systematic risk and expected returns on assets. The formula for calculating the expected return of an asset given its risk is as follows:

$ER_i = R_f + \beta_i(ER_m - R_f)$, *where* ER_i *= expected return on investment;* R_f *= risk-free rate;* β_i*= beta of the investment; and* $(ER_m - R_f)$ *= market risk premium.*

[13] Before 2019 the discount rate was fixed at 10 per cent.

National Energy Commission	This agency, created in 1978, is linked to the President of the Republic through the Ministry of Energy. It is responsible for determining prices, tariffs and technical standards that electricity companies must follow. It develops the annual plans for the expansion of the transmission system, taking into account the five-year prospective plan developed by the Ministry. It designs, coordinates and directs the implementation of the auctions that distribution companies must call to contract the supply of electricity for their regulated customers.
Electricity and Fuels Superintendence	Created in 1985, it is linked to the President of the Republic through the Ministry of Energy. It ensures that companies comply with the sector's regulations and that the Coordinator fulfils its functions and legal obligations. It receives and resolves user complaints and determines whether firms must compensate users in the event of a service outage.
National Independent Coordinator	Headed by a five-member Board, the Coordinator is responsible for, among other tasks, (i) formulating the system's operation and maintenance programmes; (ii) carrying out the dispatch; (iii) calculating the hourly marginal costs of the system; (iv) computing the economic transfers between companies; and (v) carrying out international auctions for the construction and operation of the new transmission projects and the expansion of existing ones. The Board members are elected by a committee composed of the head of the National Energy Commission, a councillor of the System of Senior Public Officials Council, a member of the Energy Expert Panel and a judge of the Competition Tribunal.
Energy Expert Panel	Created in 1994, its members are appointed by the Competition Tribunal. It rules on the discrepancies submitted to it about (i) the matters expressly indicated in the laws and (ii) those arising between the Coordinator and the companies subject to its coordination concerning internal procedures, instructions and any other act of coordination of the operation of the system and the electricity market. The rulings are binding on all those who participate in the process, and no ordinary or extraordinary appeals of a jurisdictional or administrative nature are admissible.

Source: Authors' compilation

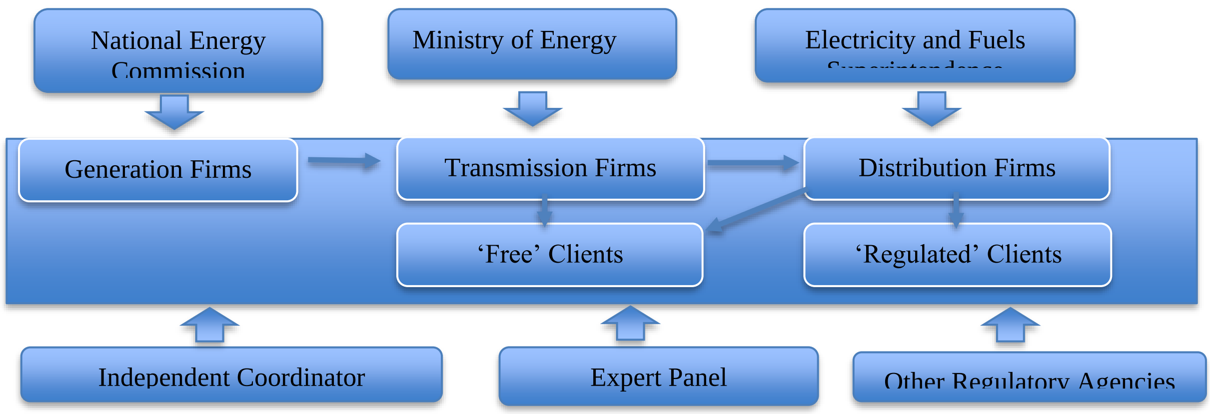

Figure 5: Chilean power sector institutional setup
Source: Authors' compilation

The electricity companies also interact with the Environmental Evaluation Service, which approves the Environmental Qualification Resolutions required for developing new projects, and the Superintendence of the Environment, which monitors compliance with environmental regulations. Their decisions may be appealed before the Environmental Courts.

2.1.3. Tariff levels and financial sustainability

The risk profile of the largest electricity companies in Chile is moderate (Table 3). The financial health of the sector is better measured under conditions of systemic stress,[14] situations for which risk classifications have not proved to be reliable. The Chilean system has experienced and survived a number of these situations.

Table 3: Fitch ratings of Chilean electricity companies

Company	Date	Distribution (%)	Transmission (%)	Generation (%)	Ratings	
					Local	Inter.
Chilquinta Energía S.A.	Nov 2020	85	15		AA	
Compañía General de Electricidad S.A.	April 2019	66	34		A+	
Transelec S.A.	Jan 2020		100		AA-	BBB
Engie Energía Chile S.A.	June 2020			100	AA	BBB+
AES Gener S.A.	July 2020			100	A+	BBB-
ENEL Chile S.A.	Jan 2011	20		80	AA+	A-
Colbún S.A.	Dec 2020			100	AA	BBB+

Source: https://www.fitchratings.com/

The risk of non-payment for generators holding contracts to supply regulated customers is low. The contract off-takers – the distribution companies – have a low insolvency risk. The tariffs of these companies are set through processes that offer guarantees to the parties. The Expert Panel resolves discrepancies. The risk of regulatory expropriation is therefore remote.

2.1.4. Policy framework

The objective of the country's electricity policy is to ensure a safe and efficient supply with a low impact on the environment. At present, the focus is on reducing emissions and increasing competition in the auctions to supply regulated customers. Section 3 looks at the second goal. Regarding the first policy objective, it aims at reducing pollution in the so-called sacrifice zones and contributing to the global reduction of greenhouse gas emissions, in response to both social demands and international commitments.[15]

The main tool to reduce greenhouse gas emissions is the promotion of RE, excluding hydroelectric plants with a capacity of more than 20 MW. In 2005, a legal amendment exempted RE plants smaller than 9 MW from paying transmission tolls, and plants between 9 and 20 MW

[14] An example is the potential insolvency of a generator that has withdrawn more energy to supply its customers than it injected into the system, and it therefore owes money to the other generators. Also, the authorities have amended the law to reduce this risk, so it seems less likely.

[15] Chile's 'National Contribution to the Paris Climate Agreement 2015' commits the country to a 30 per cent reduction in greenhouse gas emissions per unit of GDP by 2030, in comparison to the 2007 level.

received a proportional benefit. It also gave RE generators the right to supply up to 5 per cent of total regulated customer demand at the average price of standing contracts.

No RE generator used this right to supply because the price was not attractive and in 2008 a new amendment replaced it with a renewable energy power obligation (REPO). The REPO stipulates that at least 10 per cent of the energy that generators with an installed capacity of more than 200 MW withdraw from the system to supply their customers has to come from their own or contracted RE facilities. The non-compliance fee is 0.4 UTM (≈US$25) for each MWh of RE deficit.

In 2013, the government changed the Act again to raise the REPO to 20 per cent. It also established that the Ministry of Energy would conduct up to two public auctions per year for the portion of the REPO not covered.[16] So far, it has not been necessary to hold these auctions, and it is unlikely that this will happen in the future since RE has been so competitive in the 'normal' auctions.

Finally, the 2016 law change shifted the obligation for financing non-DTSs to consumers benefiting RE generators as they make greater use of transmission facilities due to their location farther away from demand centres. The definition of DPTSs was also intended to favour RE expansion as it allows the construction of a single transmission system to evacuate the energy for all the plants in the area, taking advantage of scale economies. Generators would only pay for the capacity they use. So far, the Ministry has not identified any development pole.[17]

Planning

Every five years, the Ministry of Energy carries out a 30-year prospective study of the electricity sector called the energy planning process. It includes electricity supply and demand projections. This study is the basis for developing plans, policies and regulations for the proper functioning and development of the sector.

The Commission, taking into account the Ministry's prospective study, carries out the annual transmission planning process mentioned earlier. Its objective is to identify the expansion projects required by the system, considering a horizon of at least 20 years.

The government does not undertake distribution planning, although the tariff setting process considers non-binding expansion plans. Nevertheless, distribution companies are obliged to provide service to anyone who requests it and failure to comply with this requirement could lead to the cancellation of the concession.

Regarding generation, there is no formal planning process beyond the prospective study carried out by the Ministry, but authorities have diverse tools to oversee capacity sufficiency. First, the annual power sufficiency balance that measures the system's ability to supply peak demand alerts authorities about potential capacity gaps. Second, every year the Commission prepares the Auction Report, described in section 3.1.1, with projections of the expected availability of electricity in the following years.

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[16] Since the amendment has transitional articles that lower the requirement for existing energy supply contracts, the 20 per cent requirement will only come into full force in 2025.

[17] These pole areas resemble the South African Renewable Energy Development Zones (REDZs), which are defined as geographical areas most suitable for the rollout of wind and solar energy projects and the supporting electricity grid network (McEwan, 2017).

3. Energy auctions

This section analyses the legal framework introduced in 2005 that has governed the 15 energy auctions held since then (see Table 4).[18] It initially obliged distribution companies – individually or collectively – to carry out auctions three years in advance for long-term contracts (up to 15 years) to supply energy and, indirectly, power for their regulated customers. Auctioneers had to choose the combination of bids that minimised their supply costs. The award prices are the bid prices (pay-as-bid). The off-takers are the distribution companies that pass on the award prices to consumers.

While the auctions are for the supply of electricity, the auction rules require bidders to specify the capacity that supports their bids. This prequalification condition is technology-neutral and can include uncontracted standing installed capacity or new projects.

In 2015, authorities dissatisfied with the auctions' outcomes amended the Act to expand the role of the Commission and increase competition, especially by reducing the risks to entrants. The main changes were: (i) to entrust the Commission with the responsibility of convening, designing, coordinating, and directing the execution of the auctions; (ii) keeping price ceilings reserved until the opening of bids; (iii) increasing the time to start supply to five years; and (iv) extending the maximum duration of contracts to 20 years.

The reform also allowed awardees who supported their bids with projects to request their postponement for up to two years, or the termination of the contract if, for reasons beyond their control, the projects were delayed or proved unfeasible. The auction rules have established rates of 10 UF (US$409) per month of delay and 360 UF (US$14 730) for the termination of the contract per GWh contracted for the last year of the contract (LYOC). Awardees can make these requests up to three years after the contract is signed. Auction rules also allow an awardee to request a contract change in the event of permanent changes in regulations or taxes that significantly increase costs.[19]

The 2015 amendment to the Electricity Act also provides that auctioneers should minimise the cost of supply, taking into account supply security and diversification objectives. The diversification objective led to the decision to tender supply contracts for time blocks that fit the generation profile of variable RE technologies, such as a day block (8am–6pm) tailored to PV generation or an evening block (6pm–11pm) in line with the profile of wind generation. Time blocks purport to reduce the risk of spot price exposure for variable RE means and thus encourage their installation, as explained below.

[18] Until 1998, distribution companies bought energy for their regulated customers at a price set by the regulator. From that year onwards, distributors had to auction supply contracts at a price that could not exceed a ceiling set by the regulator. The 2005 amendment to the Act gave the auctions their current design.

[19] The 2017 and 2019 auction terms consider a cost increase of 2 per cent or more to be significant, while in 2015 the figure was 10 per cent. The Commission should authorise any contractual amendment, and interested parties, including consumer associations, may appeal against the decision to the Expert Panel.

Table 4: Key auction information

Design	Year of introduction	2005
	Frequency of auctions/rounds	15 rounds to date
	Volume requested per auction (maximums)	2015: 1 200 GWh/year 2016: 12 430 GWh/year 2017: 2 200 GWh/year Demand is divided into hourly or quarterly blocks. Volume is determined by the Commission based on demand estimations by the distribution companies.
	Technology requested (Supply specification)	Technology neutral (includes fossil fuels)
	Power purchase agreement length	20 years (before 2015: 15 years)
	Currency	US$. Energy price indexed to the weighted average of five international price indexes with weights chosen by bidders. Capacity price indexed to the US consumer price index (CPI).
Implementation	Policy and regulation guidelines	Energy Ministry
	Regulatory authority	National Energy Commission
	Procurer	National Energy Commission
	Off-taker	Distribution companies
Outcomes	MWh procured	2015: 1 200 GWh/year 2016: 12 430 GWh/year 2017: 2 200 GWh/year
	Capacity of projects backing successful bids	Wind 4 716, Solar 2 427, Mini hydro 18
	Prices (2017, US ¢/kWh)	Energy: Average: 3,25 Daytime block (8am–6pm), Average: 3,16, Lowest bid: 2,15 (Solar PV) Capacity (power): 7.9980 US$/kW/mes (set in auction rules)

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

Awardees' power payments

Each successful bidder receives from distribution companies to which it supplies energy, in addition to the energy payment, a capacity payment, which is determined as follows. In each billing period, every distribution company allocates among its suppliers the amount of energy it withdrew at the hour of peak demand in the system, based on the amount of energy that each awardee supplied during the time block in which the maximum hourly demand was recorded. Every distributor pays its suppliers the amount of energy it has allocated to each one, valued at the capacity price set out in the auction rules.

Each distributor informs the Coordinator of the allocation among the suppliers of its energy withdrawal at the system's peak demand hour. Thus, in calculating the system's balance of sufficiency power, the sum of the sufficiency powers that the distributors assign to a generator counts as a deduction.

3.1. Auction design

The information below considers the rules for the three auctions held after the 2015 legal change. They are similar, except for the significant increase in guarantees required from 2017, which includes the introduction of a performance bond, the doubling of the bid bond per unit, and the requirement for bidders to show that their projected capacity is enough to supply their contracts. This change may be a response to concerns about the economic viability of contracts awarded in previous years at prices that some analysts considered surprisingly low (Cruzate, 2017; del Rio, 2017). However, bid prices fell sharply again in the 2017 auction.

The auction process begins with an international request for proposals and the publication of the auction terms. Potential bidders have three months to consult the auctioneers about the auction rules. Auctioneers, in turn, have approximately one month to provide public responses. The deadline for submitting proposals is about six months after the beginning of the process (Table 5).

Bidders submit administrative and financial proposals in separate sealed envelopes. The auctioneer first opens the administrative envelope, and those bidders that pass this stage go on to the next one. Then the ceiling prices are revealed, and the bidders whose price bids exceed them can modify their bids according to directions set in the auction rules (see section 3.1.3), after which comes the opening of the financial proposals in a public act. Finally, the auctioneer chooses the winning bids.

Table 5: Schedule of three last auctions

2015-02	2015-01	2017-01	Stage
19 June 2015	29 May 2015	30 Jan 2017	International call for tenders. Both the consultation period and the sale of the auction terms start.
7 Aug 2015	30 Dec 2015	26 April 2017	End of consultation period.
26 Aug 2015	29 Jan 2016	31 May 2017	Last date for answering queries.
28 Aug 2015	11 July 2016	11 Aug 2017	Last date to modify the auction bases.
14 Oct 2015	27 July 2016	11 Oct 2017	Deadline for submission of proposals.
14 Oct 2015	4 Aug 2016	19 Oct 2017	Publication of evaluation of administrative proposals.
21 Oct 2015	9 Aug 2016	24 Oct 2017	Day for submitting rectified administrative proposals. Opening of the envelope with the ceiling price.
19 Oct 2015	12 Aug 2016	26 Oct 2017	Day for submitting rectified economic proposals.
23 Oct 2015	16 Aug 2016	30 Oct 2017	Public release of economic offers.
26 Oct 2015	17 Aug 2016	3 Nov 2017	Announcement of awardees in first round or call for second round of bids.
4 Nov 2015	25 Aug 2016	9 Nov 2017	Second-round bid submission (if needed).
4 Nov 2015	25 Aug 2016	10 Nov 2017	Declaration of second-round awardees (if needed).
10 Nov 2015	31 Aug 2016	15 Nov 2017	Day to report the result of the auction to Commission.
4 March 2016	30 Sept 2016	15 Dec 2017	Contract signing.
4 March 2016	30 Oct 2016	15 Jan 2018	Contract registration in the Electricity and Fuels Superintendence.

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

3.1.1. Auction demand

The Act establishes that each year the Commission must prepare an Auction Report projecting the supply auctions to be held in the following four years, considering the obligation of the distributors to contract the energy to supply their regulated customers five years in advance. To do so, it must project demand based on data provided by the distributors and the expected availability of electricity in the corresponding period.

Once the report has been drawn up, the Commission initiates an auction if determined to be necessary.[20] It also prepares and publicises the auction rules, which must specify, at least, the amount of energy to be tendered, the supply blocks, the years that the contract covers, and the criteria and methodologies for the economic evaluation of bids.

A generator that wins a contract in Block A supplies energy to the contracting distribution company during that period. In the 2017 auction, for instance, three hourly blocks were offered: Block A: between 00:00am and 07:59am and between 11:00pm and 11:59pm; Block B: between 08:00am and 5:59pm; and Block C: between 6:00pm and 10:59pm.

The 2017 auction also tendered quarterly (seasonal) blocks, having in mind run-of-river hydropower plants which have greater water availability in the third and fourth quarters of the year, because of winter rains followed by the melting of mountain snow (James, 2017). In this auction, two bidders with run-of-river hydropower projects submitted bids for the third and fourth quarters, but neither won. The terms for the cancelled 2019 auction did not repeat the quarterly blocks.

The auction rules also divide the time blocks into sub-blocks to facilitate small firms' participation. The sub-blocks are simply a fraction of the total block, usually of equal size. For example, a 5 000 MW time block can be subdivided into 100 sub-blocks of 50 MW each. Bidders can submit a bid price for each sub-block or packages of them. They can also condition a bid submitted for a package of sub-blocks on winning a minimum number of them. For example, a bidder who submits a tender for 80 sub-blocks in Block A may condition it on winning at least 60.[21] Bidders may furthermore link bundles of different blocks into a conditioned bid. A generator may submit offers to supply 50 and 40 sub-blocks in Blocks A and B, respectively, but conditioned on winning both bundles or neither.[22] These conditioned bids are referred to as linked bids.

3.1.2. Qualification criteria and process

The law establishes that a by-law will determine the requirements and conditions that bidders must satisfy. The by-law further expands on these obligations but relegates the details to the auction rules. The following summarises the requirements of the 2015 through 2017 auctions. Parties interested in participating in an auction must first acquire the auction rules. To bid, they

[20] This report is subject to the same regime of observations submitted to the Commission and dispute adjudication by the Panel as any other regulatory action of the Commission.

[21] The need that bidders may have of contracting a minimum amount of energy to build a project justifies this restriction.

[22] A potential bidder with a dispatchable generation technology can make a more competitive bid by ensuring the sale of energy through the day at attractive prices, and not only at certain hours of the day.

need to provide specified legal and financial company documents, detail the generation sources that support their bids, and provide a bid bond. There are no additional requirements.

Legal and financial prequalification

Chilean or foreign legal entities may participate in the auctions under the same conditions, either individually or in a consortium or association. Bidders that are not a corporation or a joint-stock company incorporated in Chile with power generation as its only line of business are obliged to constitute one if they win a contract. To this end, they must provide a guarantee of UF100 (US$4 090) for each GWh offered for the LYOC.

Bidders must also submit audited financial statements for the previous three years and be rated no less than BB+ (Chilean classification) by one of the risk rating companies listed in the auction rules.[23] For bidders that back their bids with new generation projects, a risk classification report prepared by one of the risk rating companies listed in the terms must evaluate the projects, including the experience in the field of the developer and/or sponsor of the projects.

a. Bid bonds

In the 2017 auction, bidders had to provide bid bonds of UF200 (US$8 180) for each GWh offered for the LYOC, double the requirement of previous auctions. The auctioneers must collect the bid bond when a bidder withdraws its bid or fails to comply with the auction rules. Unsuccessful bidders' bonds are returned. Awardees receive their bid bonds back once they have signed the respective supply contract and delivered the guarantees provided for in the contract (see section 3.1.4.1), including a performance bond as of 2017.

b. Generation sources that back up the bid

Bidders must identify existing and projected power generation sources backing up their offers, specifying the technology, installed capacity, current or planned location, start-up date when applicable, primary fuel (and its provider) when applicable, current or planned point of connection to the system, and the expected capacity factors. There are no caps on project sizes.

Bidders must also indicate both their current contracts with free and regulated customers and their expected generation capacities, based on both design capacity and the projected capacity factors for the first five years of the supply period. Moreover, from 2017 onwards, the auction terms restrict bidders to offering an amount of energy not exceeding their expected capacity minus the amount of energy currently contracted for that period. The 2019 cancelled auction terms further applied this condition to each time block.

Bidders proposing new projects must submit a Gantt chart with the construction milestones, including obtaining the environmental permit and electrical concessions; ordering major equipment; commencing construction; achieving 25, 50, 75 and 100 per cent, respectively, of work progress; testing interconnection; and entry into operation. A technical auditor selected by the awardee from the public registry of consultants evaluates the fulfilment of the milestones. Non-compliance with the construction schedule results in the sanctions detailed in section 3.1.4.1.

[23] Risk rating companies must be established in Chile, although some are local branches of international companies such as Moody's, Standard and Poor's, and Fitch Ratings.

The 2019 auction terms established that in duly justified cases,[24] awardees may request the replacement of a project by another, paying a penalty of 50 UF per GWh (approximately US$2 046) of energy awarded for the LYOC.

Awardees are responsible for connecting their plants to the nearest transmission system. They pay transmission tolls if they feed their energy into the national grid through dedicated systems. The Act provides guidelines for calculating the tolls, and generators can appeal to the Panel if they disagree with the owners' calculations. The design of development zone systems must consider the ability to meet all foreseeable demand, but owners of dedicated systems are not obliged to expand them.

Information on the availability of transmission capacity is available to generators through the annual transmission system expansion plans, which contain all information on transmission. The auction terms establish that delays in the entry into operation of the transmission lines included in the expansion plan in force on the date of submission of bids, and to the extent that such delays prevent compliance with the contract, constitute force majeure,[25] to determine the contractual responsibilities of the successful bidders described in section 3.1.4.1.

On the other hand, since the contracts are awarded five years before the start of supply, this information is available for the annual transmission planning processes. Likewise, the auction rules provide that distributors must inform the Commission yearly of the increases in power demand that they will require for the following years per withdrawal point in the system.

Bidders that back up their submissions with new projects procure their own sites. They can purchase or rent land from private owners or bid for a 40-year public land concession in the auctions that the Ministry of National Properties carries out.[26] In the case of geothermal projects potential bidders have to request exploration and exploitation concessions from the Ministry of Energy. The Commission website provides information on the conditions for PV and wind generation throughout the territory.[27]

The north of Chile, mainly the Atacama and Antofagasta regions, has the highest concentration of PV farms due to the appropriate climatic conditions. Wind resources for the installation of wind farms are more distributed throughout the coastal zones. However, wind farms also tend to be located in the northern zone, where they have a lower environmental impact and encounter less social rejection due to lower population density.

The Atacama and Antofagasta have large areas of desert, a significant part of which is public property, with limited occupation by mining operations. Therefore, finding sites for RE projects should not be hard. However, given that generators pay the costs of interconnecting to the transmission system, there is competition for land close to electrical substations, especially those in the national grid, to avoid paying use-of-system charges to the owners of DTSs.

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[24] No details are available on what would constitute duly justified cases. Since it has never been applied, there is no case law on the matter.

[25] Article 45 of the Civil Code defines force majeure as an unforeseen event that cannot be resisted, such as a shipwreck, an earthquake, the capture of enemies and acts of authority by a public official.

[26] The bidding variables are the annual lease, the percentage of the yearly income from injected energy offered and the installed capacity per hectare.

[27] The Solar Resource and Meteorological Data Scan offers information on radiation (global horizontal, global inclined, direct normal and diffuse horizontal) and meteorological conditions (cloud frequency, temperature and wind speed) (Molina et al., 2017). In turn, the Wind Energy Explorer is a tool for the analysis of wind resources, which provides the results of a numerical simulation of wind and air density conditions and a wind generation calculator for each point of the country.

The city of Antofagasta, capital of the region of the same name, is 418 km north of Copiapó, capital of the Atacama region, which in turn is 678 km north of Santiago, the country's capital and main demand centre. The northern regions, despite the substantial energy demand from local mining activities, should produce RE surpluses, which the BNIS-CIS interconnection in 2018 and its subsequent strengthening should make it possible to transport.

The regulations establish 'early' qualification criteria in the sense that they do not require bidders to have environmental permits, land rights, interconnection agreements or a commitment from the lender before the bidding. The construction milestones to be met by successful bidders include these requirements explicitly or implicitly.

Bidders are nonetheless likely to have all these documents ready or at a very advanced stage before they bid. Getting environmental permits approved is a long, uncertain process that adds significant realisation risk. Also, where a bidder has already been awarded a contract with a specific project, its bargaining power concerning land rights and interconnection agreements is low. Thirdly, delays in reaching commercial operation result in heavy penalties and financial liabilities being levied, discussed in section 3.1.4.1, a risk that bidders try to avert.

3.1.3. Winner selection

The law establishes that auctions must minimise the cost of supply, taking into account the objective of diversification of generation, which so far has materialised through the introduction of time blocks, as explained above. The award criterion does not include social aspects such as the percentage of domestic ownership or local labour. Nor does it impose any limit on the energy that auctioneers can allocate to a single bidder. The Commission defines the formulas for indexing the award prices or the framework within which the bidders can set them and decides whether the evaluation of bids takes account of the indexation formulas.

The most recent auctions required bidders to indicate the following for each of their bids: (i) the bid price in US$/MWh; (ii) the minimum number of sub-blocks to win; (iii) possible links between bids submitted to different blocks; and (iv) the weights parameters of a price indexation formula that is a weighted average of five price indexes (four fuel price indexes and the US CPI), where the sum of the fuel index weights cannot exceed 0.7.[28] The auctioneers must choose a combination of bids that minimises the total cost of supplying all of the energy requirements using the present value of projected bid prices, the so-called levelised bid prices.[29]

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[28] The fuel prices are the monthly diesel oil parity price, the monthly average of daily Brent crude oil based on Argusen's reports, the monthly coal parity price, calculated by the Commission based on the Platts International Coal Report for FOB prices and Shipping Intelligence Weekly for ocean freight, and the Henry Hub natural gas monthly average price. Bidders whose projects do not use fuels may choose to have their prices indexed 100 per cent to CPI.

[29] The levelised price is the average for the first ten years of supply of the present values of the bid prices projected according to the indexation formula proposed by the bidder, discounted at a rate of 10 per cent. Denoting P_{bid} the bid price, PPI the price index projection, EB the energy offered, Start the number of years between the bid submission and the beginning of the supply (six), N the number of years considered in the projection (ten), and *r* the annual discount rate (10%), the formal expression for levelised prices is:

$$P_{levelized} = \frac{\sum_{i=0}^{N-1}\left(\frac{P_{bid}\cdot PPI_{Start+i}\cdot EB_{Start+i}}{(1+r)^{Start+i}}\right)}{\sum_{i=0}^{N-1}\left(\frac{EB_{Start+i}}{(1+r)^{Start+i}}\right)}$$

Example

Consider an auction supplying annually two blocks of 60 000 MWh and 40 000 MWh, respectively, each divided into 100 sub-blocks. Two bidders make bids. Bidder 1 offers (a levelised price of) US$50/MWh for 100 sub-blocks in both blocks, and bidder 2 offers US$30/MWh for 80 sub-blocks in the second block. All three bids are unconditional. In this case, bidder 1 is awarded the entire Block 1 and 20 sub-blocks in Block 2, and bidder 2 is awarded 80 sub-blocks in Block 2.

Next, imagine that bidder 1 makes the bid in Block 2 conditional on being awarded all the sub-blocks. In this case, bidder 1 wins both complete blocks. By adding a third bidder who bids US$60/MWh for 30 sub-blocks in Block 2, the combination that allows the supply of all demand at minimum cost would award the entire Block 1 to bidder 1, 80 sub-blocks in Block 2 to bidder 2, and the remaining 20 sub-blocks in Block 2 to the third bidder. In this context, if bidder 1 conditions its bids on winning both or neither of the two blocks, it wins both.

The auction rules also provide that, after the public opening of the financial envelopes, a generator that offered a price that exceeded the ceiling price may match it if the initial price bid was lower than the ceiling price plus a reserve margin, or the ceiling price less a predetermined percentage if it was not. This percentage was 3 per cent in the auctions of 2015 and 2016, and 5 per cent in the following auctions. The reserve margin was 2.5 per cent in the 2017 auction.

3.1.4. Buyer and seller liabilities

3.1.4.1. Guarantee requirements and penalties

The auction terms require bids to include a liability insurance policy covering damage of any nature caused to facility personnel, third party property or the environment, and a disaster insurance policy to rebuild or repair facilities damaged during construction, where appropriate, and their operation. The minimum coverage under each of these guarantees is CH$3 000 000 (US$4 200 using the 31 December 2020 exchange rate). The 2017 auction rules also required awardees to provide a performance bond for 600 UF (US$24 549) per GWh in the LYOC, valid for up to 15 months after the start date of supply.

Non-compliance penalties range from the loss of the contract to the forfeiture of the performance bond. Auctioneers must execute the performance bond of an awardee for the benefit of regulated customers when, inter alia: (i) the awardee fails to fulfil its supply commitment during the first 12 months; (ii) the contract is terminated early for reasons attributable to the supplier; and (iii) the project that supports the bid is not put into operation at least two months before the expiration of the performance bond if applicable. Auctioneers may claim compensation for damages not covered by the performance bond in the event of contract non-compliance.

For an awardee that backed its bid with a project, a delay of more than 60 days for the fulfilment of two construction milestones (as per the Gantt chart) results in a fine of UF30 (US$1 228) for each GWh in the LYOC. Failure to pay this penalty within 30 days results in the collection of the performance bond.

The distributors are obliged to terminate a contract in advance, with the prior approval of the Commission and without any compensation to the awardee, if: (i) the awardee fails to comply with the obligations arising from its participation in the balance of injections and withdrawals of energy and power during two consecutive months; (ii) a court issues a resolution liquidating the supplier; and (iii) the supplier incurs serious and repeated breaches of the contractual obligations that are attributable to it and does not remedy them within 30 days.

Furthermore, the distributor may terminate the contract early if the supplier is in serious breach of its contractual obligations that is not remedied within 90 days;[30] obtains a risk rating lower than BB+ during the term of the contract and does not improve it within 12 months; and if the performance bond is executed.

3.1.4.2. Risk allocation

The auction design seeks to reduce bidders' risks to obtain more competitive prices. The choices regarding contract lengths, price indexation and currency selection expressed in the bidding terms reflect this policy. Award prices are denominated in US dollars and are adjusted every six months: the energy price according to the formula detailed in section 3.1.3, and the power price according to the variation of the US CPI.[31] Besides, the aforementioned clauses that allow awardees to request modification or termination of the contract also tend to reduce their risk.

Successful bidders, however, face a demand risk with their contracts, as they only invoice for the actual demand of the distribution companies and not the maximum amounts set out in the contracts. In recent years, many regulated consumers have chosen to deregulate (Figure 6). This migration is due to the rise in the regulated price resulting from high auction award prices up to 2014, in parallel with a sharp fall in the spot price. As a result, successful bidders will sell less energy at contracted prices and more at spot prices.

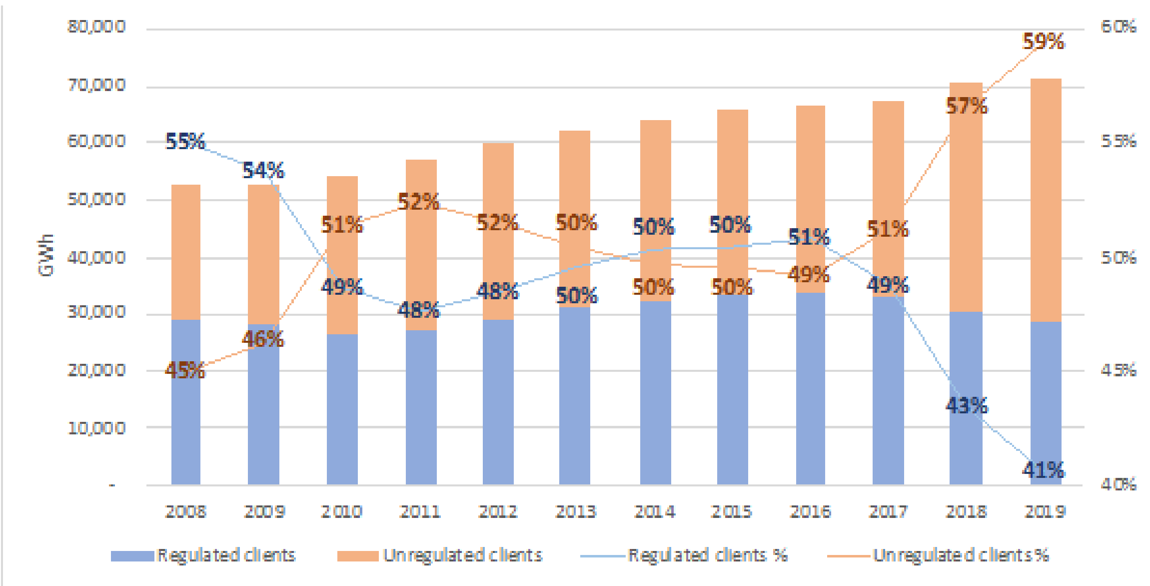

Figure 6: Evolution of energy withdrawals

Source: Yearbook NEC, 2019

This situation will have a greater impact on small, undiversified, variable RE generators, since exposure to the spot price represents a greater risk for them. Moreover, for their contract sales they will receive the most competitive prices recorded from 2015 onwards, when they started

[30] In this case, the breach does not have to be repeated.

[31] If the indexation were the same in both cases, a contract's awardee would receive a power payment based on its sufficiency power. Furthermore, the way in which a distributor allocates its power consumption among its suppliers would become irrelevant.

to bid, unlike large companies that were awarded contracts auctioned before 2015 at high prices (see section 4).

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

The contracts' off-takers – distribution companies – are investment grade. They are authorised to cut off service to their customers who have unpaid bills, so they have a low rate of non-collection,[32] in the order of 1 per cent, which is also considered in the calculation of tariffs. The Commission approves the supply contracts which are signed by public deed with the distribution companies. As a result, the possibility of distributors not paying generators for power withdrawn has so far been remote. Moreover, bidders are paid in US dollars and prices are indexed to costs, effectively shielding them from FX fluctuations and inflation.

3.2. Auction implementation

Auctions have generally enjoyed wide-ranging support. When co-legislators introduced the new auction design in 2005, there was relative consensus in Congress. Also, industry analysts generally had a favourable opinion of the changes introduced, except for some specific criticisms (Bustos-Savagno, 2019; Moreno et al., 2012). Lately, however, there have been voices questioning the outcomes of auctions between 2010 and 2014, which resulted in the awarding of contracts at very high prices.[33]

The social unrest that started in October 2019 forced the government to postpone the price increase for regulated consumers that should have taken effect in November 2019. The more recent auctions were highly competitive, and distributors were able to award contracts at significantly lower prices than in 2010–2014. Thus, no political or social rejection is expected in the future.

The institutions in charge of implementing the auctions are the Commission and the distribution companies. The former is responsible for convening, designing, coordinating and directing their implementation, which includes writing the auction rules and preparing the standard supply contract to be signed by auctioneers and awardees.[34] The Commission formalises the contracts by means of an administrative act after being informed by the auctioneers on the evaluation and award of the contracts.

The distribution companies, for their part, carry out the auction processes subject to the rules and other requirements set by the Commission. In that sense, they are responsible for the administrative aspects of the auctions. Between 2006 and 2011, the distribution companies held simultaneous auctions with a coordinated award mechanism that allocated all contracts. The contracts differed between companies in terms of duration and price. Since 2012 they carry out centralised auctions for the sum of their demands. To do so, they appoint a person to run each auction on their behalf.

These institutions are the natural choice to implement the auction processes. The distributors are the contract off-takers and are in charge of managing them. For instance, they inform the

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[32] Due to the pandemic, Congress enacted a law allowing regulated consumers to defer payment for service.

[33] https://www.emol.com/noticias/Economia/2017/11/16/883537/Cuentas-de-luz-subirian-12-al-2020-por-altos-precios-en-licitaciones-con-modelo-antiguo.html

[34] Until the 2015 legal change, the Act provided that the Commission approved the auction rules and that auctioneers informed it of the results. The disappointing auction outcomes in early 2010 and the expertise acquired by the Commission over ten years of monitoring the auctions explain these changes.

system Coordinator about the allocation among the various suppliers of their energy withdrawals and power requirements. For its part, the Commission, as a regulatory body, has a direct interest in the auctions for the supply of energy to regulated customers.

The distributors have the capacity and experience to carry out complex auctions in different areas, as they recurrently tender the construction of new facilities. Also, between 1998 and 2005, they carried out energy supply auctions for the supply of their regulated customers, although in a different legal framework. The Commission is recognised for its technical capacity and has considerable experience in supervising auctions.

The distribution companies must bear the expenses incurred in the implementation of the auction processes. In return, the Act establishes that the auction terms may regulate the use of the resources obtained from the sale of auction terms (RfP documentation and contracts), which must be limited to the financing of activities related to the auction processes. In the 2019 auction, the cost of terms was CH$2 million plus VAT (US$2 815).

Two regulatory features strengthen the integrity of the process: the obligation of transparency and the supervision by the Commission. The Act provides that auctions shall be public, non-discriminatory and transparent. It also provides for the electronic publication (the official webpage of the auctions, Commission, Electricity and Fuels Superintendence and Coordinator) of the precise timetable with the process milestones. Some of these correspond to public activities, including the reception of administrative and financial proposals and their subsequent opening, of which notarised minutes are taken. Likewise, the auctioneers must draw up notarised minutes of the evaluation of the administrative proposal and the award of the financial bids. Auctioneers must also publish the full submissions and the software used for awarding the contracts.

A second element in ensuring the integrity of the auction process is the supervisory role played by the Commission. Firstly, the Commission establishes many of the auction regulations and requirements. Secondly, auction rules require the auctioneers to report to the Commission on the fulfilment of the various calendar milestones and, in particular, on both the evaluation of the bids and the subsequent awarding of the contracts.

The Commission and the auctioneers publish the auction call on the relevant websites, as well as in a daily newspaper with national circulation. Both the consultations made by the interested parties about the auction rules, as well as the auctioneers' responses, are included in communications called clarification circulars. These are signed by the person in charge of the auction process, after approval by the Commission. The clarification circulars, as well as the notarised acts, are sent both in writing and via email to the representatives of the interested parties. They are also published on the websites mentioned above.

4. Results

Table 6 summarises the 21 auctions held in the CIS since 2006. The first column lists the administrative name of each auction, which until 2011, when distributors auctioned their supply needs separately, includes the abbreviated name of the distributor. In what follows, we group the independent but simultaneous auctions held until 2011, reducing their number to 15, and label each one with its submission deadline. In cases where it was necessary to carry out further auction rounds to award the total amount of energy offered, these are treated as separate auctions since they had different submission dates and were open to new bidders.

Table 6: Summary of auctions since 2006

Auction	Call date	Bids reception date	Award date	GWh tendered	GWh bidded	GWh awarded	Bidders	Reserve price	Mean bid price	Mean award price	Support period
2006-1-CHL	18 Apr 06	31 Oct 06	13 Nov 06	4 500	7 300	4 500	2*	62.7	56.5	53.6	1/1/2010–12/31/2022
2006-1-CHQ	6 Mar 06	31 Oct 06	13 Nov 06	910	2 044	807	3	62.7	54.5	52.2	1/1/2009–4/30/2015, 5/1/2010–4/30/2015
2006-1-SAESA	6 Mar 06	31 Oct 06	13 Nov 06	3 582	10 582	3 582	3*	62.7	54.8	49.9	1/1/2010–12/31/2019
2006-1-Emel	6 Mar 06	31 Oct 06	13 Nov 06	2 010	2 630	868	2	62.7	56.9	55.6	1/1/2010–12/31/2019
2006-1-CGE	22 Mar 06	31 Oct 06	13 Nov 06	2 310	7 010	2 310	3*	62.7	56.2	54.4	1/1/2010–12/31/2021, 1/1/2010–12/31/2013
2006-1-2-Emel	11 Dec 06	31 Jan 07	8 Feb 07	1 130	2 080	1 130	2	62.7	55.8	54.6	1/1/2010–12/31/2024
2006-2-CHL	20 Sep 06	7 Jul 07	23 Jul 07	6 600	5 700	4 200	2	61.7	60.3	59.3	1/1/2011–12/31/2021, 1/1/2011–12/31/2023, 1/1/2011–12/31/2025
2006-2-2-CHL	11 Dec 07	11 Mar 08	31 Mar 08	1 800	1 800	1 800	1	71.1	65.8	65.8	1/1/2011–12/31/2023
2008-1-CHQ	14 Jul 08	30 Jan 09	5 Feb 09	1 936	6 050	1 936	4	125.2	100.9	93.6	1/1/2010–12/31/2023
2008-1-SAESA	14 Jul 08	30 Jan 09	5 Feb 09	935	4 787	935	5	125.2	100.5	96.1	1/1/2010–12/31/2021
2008-1-CGE	17 Jun 08	30 Jan 09	5 Feb 09	5 940	18 300	4 950	5	125.2	105.6	110.1	1/1/2010–12/31/2024
2008-1-2-CGE	7 Apr 09	7 Jul 09	10 Jul 09	935	2 118	935	6	125.2	108.9	99.5	1/1/2010–12/31/2021
2010-1-CHQ	27 Oct 10	16 Mar 11	24 Mar 11	715	1 265	715	3	92.0	89.4	89.0	1/1/2013–12/31/2026, 1/1/2014–12/31/2026, 1/1/2015–12/31/2026
2010-1-CHL	27 Oct 10	16 Mar 11	24 Mar 11	1 980	2 228	1 485	1	92.0	91.1	91.0	1/1/2014–12/31/2027
2012-1	15 Mar 12	10 Apr 12	16 Apr 12	924	924	924	1	129.5	129.5	129.5	5/1/2012–12/31/2014
2012-3-2	14 Nov 12	6 Dec 12	7 Dec 12	1 650	247.5	247.5	1	134.0	138.9	138.9	1/1/2013–12/31/2014
2013-1	20 Jun 13	20 Nov 13	29 Nov 13	5 000	3 900	3 900	2	129.0	128.9	128.9	12/1/2013–12/31/2024
2013-3	30 Dec 13	5 Aug 14	14 Aug 14	5 000	750	750	1	120.2	112.0	112.0	12/1/2014–12/31/2025
2013-3-2	17 Sep 14	1 Dec 14	12 Dec 14	14 300	32 130	10 974	15	120.2	110.7	107.3	1/1/2016–12/31/2030, 1/1/2017–12/31/2031, 1/1/2018–12/31/2032, 1/1/2019–12/31/2033
2015-2	15 Jun 15	14 Oct 15	26 Oct 15	1 320	9 427	1 320	29	108.1	84.5	81.5	1/1/2017–12/31/2036
2015-1	29 May 15	27 Jul 16	17 Aug 16	12 430	98 485	12 364	61	94.0	60.3	46.9	1/1/2021–12/31/2040, 1/1/2022–12/31/2041
2017-1	30 Jan 17	11 Oct 17	2 Nov 17	2 420	13 412	2 420	22	81.5	42.7	32.5	1/1/2023–12/31/2042

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl
Note: * Gener and Guacolda count as one company.

Counting as one the groups of related bidders, we identified a total of 61 bidders in the 2015 auction process. In the following figures, we use the number of independent companies that participated in the auctions. In the last six tenders, out of 130 offers, only eight did not pass the administrative stage: one in the December 2014 auction, and seven in the October 2015 auction.

The data show two contrasting periods. Until the August 2014 auction, the number of bidders was low, and the contract award prices very high. In subsequent auctions, the number of bidders increased substantially, and the award prices showed a strong downward trend.

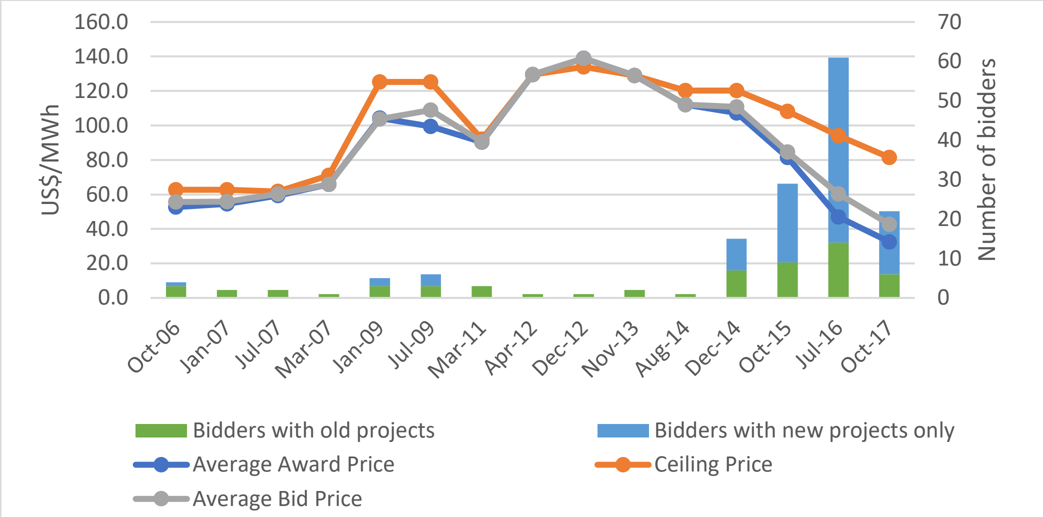

Figure 7: Energy auctions: Average bid prices, average award prices and ceiling prices
Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

As Figure 7 shows, the number of bidders was low and trending downwards until August 2014, and then rose rapidly. As of December 2014, most new bidders supported their bids only with new projects. In the 2017 auction, there was a partial trend reversal, explained by the low amount of energy offered compared with the previous auction and the steep increase in the guarantees required, which mainly affected small participants with less financial support.

Two periods can also be distinguished concerning prices. From 2006 to 2013, the award prices reached or approached the ceiling prices, with an exception in 2009 when the number of bidders showed a circumstantial increase. From 2014, the bid prices started to both move away from their ceilings and descend, reaching US$32.5/MWh in the October 2017 auction, a substantial fall from a maximum of US$138.9/MWh attained in the December 2012 auction.

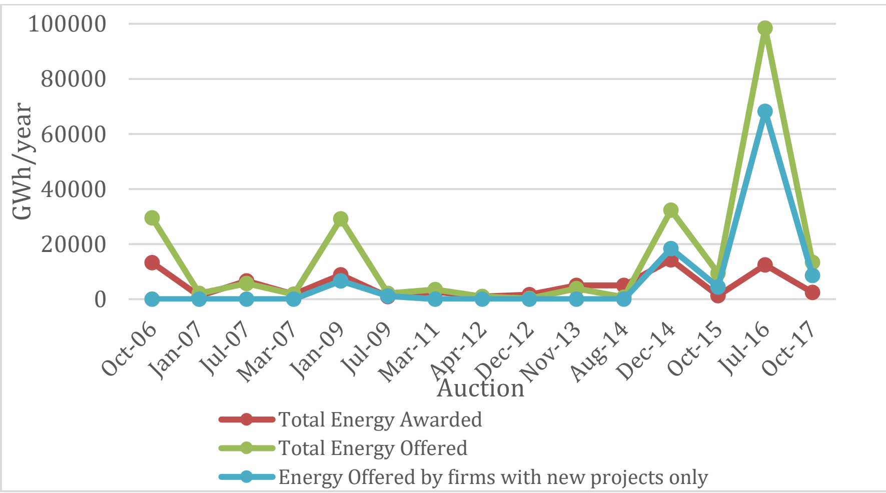

Figure 8: Energy auctioned, energy offered and energy offered by bidders with new projects

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

Figure 8 shows that in the auctions held from March 2011 through August 2014, the amount of energy submitted by bidders was either less than or slightly above the amount auctioned. From December 2014 onwards, the energy submissions far exceeded the auctioned amount, an indication of considerable competition. It also shows that the energy offers by bidders with new projects were significant from that date onwards, and enough to cover all demand.

Figure 9 shows the amount of energy awarded to bidders who partially or fully supported their bids with existing plants and those that backed their tenders with new projects only. As from the December 2014 auction, the latter group won a significant part of the energy auctioned and, in general, with slightly lower prices.

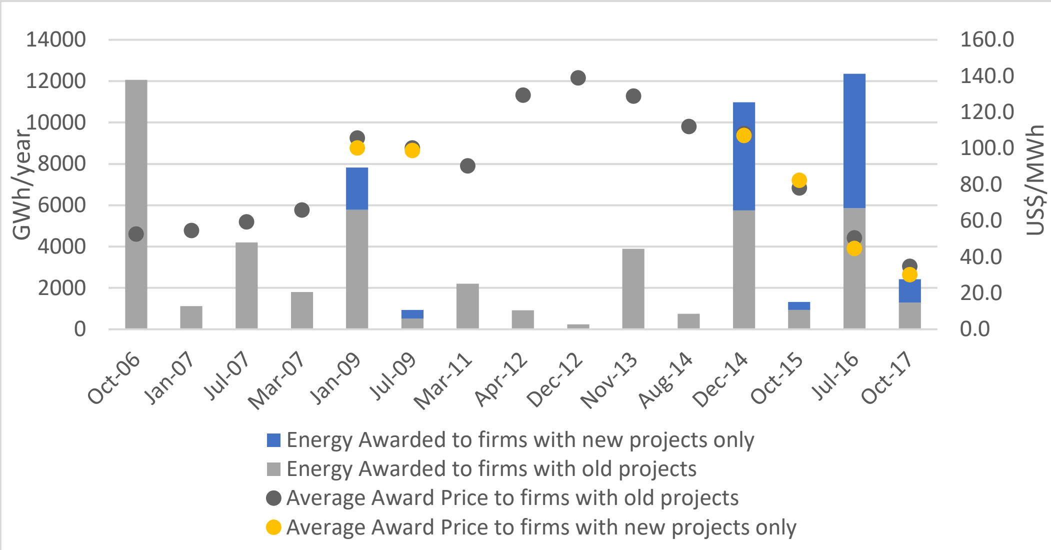

Figure 9: Energy awarded to bidders with and without old plants: Amounts and average prices

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

Table 7 shows the number and capacity of projects that have supported bids since November 2013: 91 projects with a total capacity of 11 415 MW. Most are either PV plants or wind farms. In the August 2014 bidding process, there was only one bidder without new projects.

Table 7: Technology mix of projects awarded, November 2013 to October 2017

Auction reception date	Wind		Solar		Mini hydro		Thermolectric	
	Number projects	Capacity (MW)	Number projects	Capacity (MW)	Number projects	Capacity (MW)	Number projects	Capacity (MW)
November 2013	1	61	2	100	0	0	0	0
December 2014	3	282	12	3 077	5	41	2	975
October 2015	5	547	8	571	0	0	0	0
July 2016	22	3 162	20	1 132	3	18	0	0
October 2017	5	725	3	724	0	0	0	0
Total	36	4 777	45	5 604	8	59	2	975

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

In what follows, we analyse the probable causes of the change in the auctions' outcomes as of the end of 2014. The halt in the construction of hydroelectric plants with dams in the 1990s, the principal source of power generation until then in the CIS, initially had a limited impact. From

1997, the construction of gas pipelines interconnecting with Argentina allowed for meeting power demand increases with gas-fired plants at suitable prices. With the restrictions and taxes that Argentina imposed on natural gas exports starting in 2005, spot prices jumped (Figure 10).

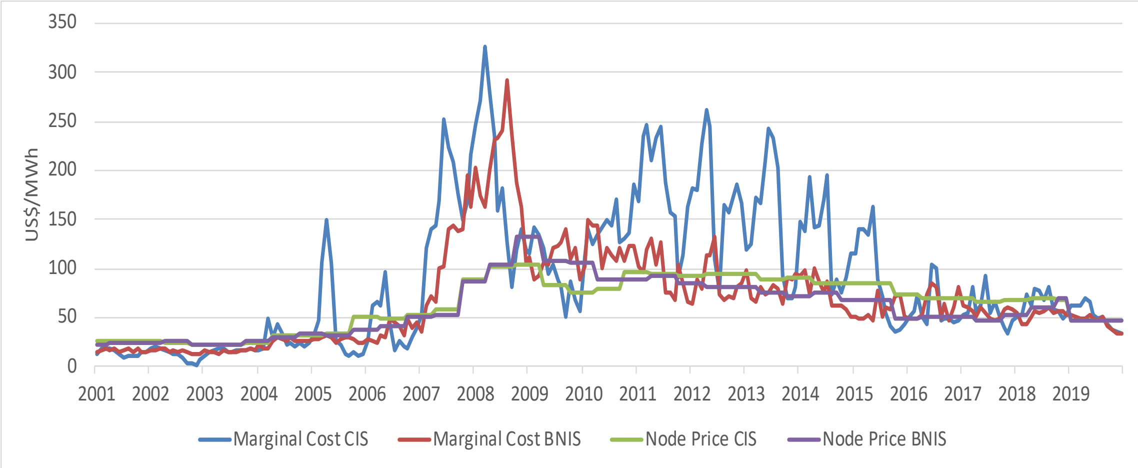

Figure 10: Monthly average spot price and node prices for NES

Source: Authors' compilation based on Coordinator (https://www.coordinador.cl/operacion/graficos/operacion-real/costo-marginal-real/) and Commission (http://energiaabierta.cl/blockchain/), 2020

Later, coal-fired plants replaced gas-fired plants as the baseload technology for supplying demand growth. However, citizen opposition made it very difficult to obtain environmental permits for their construction in the CIS, and in fact the environment authorities conceded the last approval in 2009. As a result, the possibility of building new baseload power plants was virtually closed.

This situation led to a sharp increase in the spot price in the CIS in early 2010, with average prices reaching US$183 per MWh in 2011 and US$178 in 2013, far exceeding the auction ceiling prices (Figure 10). This situation may have made it more attractive for generators to skip auctions and to reserve energy for future sale in the spot market, assuming that they did not anticipate the subsequent fall in both auction award prices and spot prices. An alternative explanation is that the few companies that owned the existing baseload plants exerted their market power as the generation costs of the backup plants exceeded the auctions' ceiling prices.

The main driver of the change in the auctions' outcomes from December 2014 seems to be the reduction in the levelised cost of electricity (LCOE) of RE technologies. IRENA (2015) reports that the global weighted average LCOE of PV halved between 2010 and 2014, a cost reduction process that continues. IRENA (2018, 2020) states that the global weighted average LCOE of utility-scale PV fell 73 per cent from 2010 for projects commissioned in 2017. In turn, the LCOEs reported by the US Energy Information Administration in the Annual Energy Outlook for projects in this country show a similar drop (Table 8).

Table 8: Levelised cost of new generation resources in the US (current US$ per KWh)

	2012	2013	2014	2015	2016	2017	2018	2019
Commercial operation date	2017	2018	2018	2020	2022	2022	2022	2023
Onshore wind	96	86.6	80.3	73.6	58.5	55.8	48	42.8
PV	152.7	144.3	130	125.3	74.2	73.7	59.1	48.8

Source: Annual Energy Outlook, US Energy Information Administration, 2012–2019. Yearly outlooks are released in December of the previous year.

This drop in RE generation costs has been especially beneficial for Chile. Few countries have as much RE potential, and as much need for RE, as Chile (del Río, 2017). The learning resulting from the incipient local investments in RE generation in the early 2010s must also have helped to reduce costs, initially driven by demand from some large unregulated customers wanting to reduce their carbon footprint and the attractiveness of injecting energy into the system without a contract due to high spot prices.

Other changes that helped increase RE's competitiveness relate to the transmission system mentioned before. First, the law change of 2016 exempted generators from paying transmission tolls. This favoured RE plants, which are usually further away from large consumption centres. Second, the interconnection in 2018 of the two major systems allowed RE plants located in the north to operate in a more flexible system that includes hydro plants with reservoirs. Finally, the reinforcement of the transmission system linking the Atacama region, which hosts most of the recent PV projects, with the main demand centres, allowed for the evacuation of energy that was spilling out due to transmission congestion.[35]

This evidence, in particular the explosive increase in RE projects, provides strong indications that the most likely cause of the sharp drop in award prices since the October auction was the decrease in RE generation costs. This cost decrease also increased competition by allowing many new companies to back their bids with RE projects.

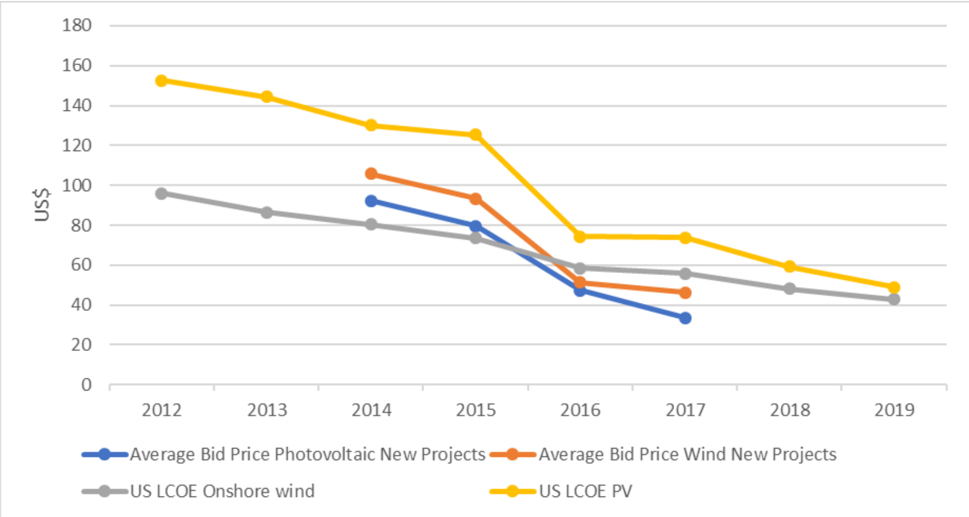

Figure 11: Average bid prices in Chilean actions by firms backing their bids with NCRE projects and US LCOE

Source: Table 8 and compiled by authors based on the database provided in https://www.licitacioneselectricas.cl

The trend in award prices in Chilean auctions is in line with those reported in IRENA's reports and the Annual Energy Outlook of the US Energy Information Administration (Table 8), as shown in Figure 11.[36] This similarity is another indication that the primary cause of the fall in the bid prices is the substantial drop in LCOEs of RE technologies, which allowed for the entry of new firms with competitive prices. In that sense, changes in legislation that reduce entry

[35] The delay in the entry into operation of the Cardones-Polpaico line of the NTS caused the spill of approximately 6 per cent of RE generation in 2018 as well as price decoupling between different nodes, with projects without contracts selling their energy at low prices and even at zero (Cruzate, 2017). RE spills decreased substantially with the start of operations of this line in May 2019.

[36] The comparisons are not so direct since in Chile the awardees face price risk, but on the other hand, they receive a capacity payment.

barriers probably also contributed to lowering prices, but to a lesser extent, an issue discussed in the next section.

In what follows, we analyse whether the auctions have been successful by considering two measures of success distinguished in the literature: cost-effectiveness (price) and investment-effectiveness (Gephart, Klessmann, & Wigand, 2017). The available evidence suggests that, at least since the end of 2014, auctions have been cost-effective, with prices in line with global trends.

The standard definition of auction investment efficiency, that is, the ability to ensure that projects reach the commercial operation successfully, does not apply directly here. Chile auctions supply contracts instead of capacity contracts. The crucial measure of success is therefore that awardees meet their obligations to pay for the energy and power withdrawn from the system by their contract counterparties. So far, only one awardee, Central Campanario, has failed to comply, despite having reached the COD on time.[37]

The Act obliges bidders to back up their bids with installed projected capacity. However, awardees that won less energy than they bid for could build fewer projects than they proposed or replace them with smaller ones. There may also be contract transfers. This information is, however, not readily available. It is nevertheless unlikely that awardees could hide project delays as independent consultants audit the construction milestones. Moreover, off-takers are legally obliged to follow up on such milestones and have no reason not to report delays or apply sanctions. The only known case of an awardee not building a project is that of Generadora Metropolitana, which won a contract in the December 2014 auction. The company backed its bid with a CCGT project, which was abandoned in 2019 due to being unable to obtain a favourable environmental resolution.[38]

[37] In 2018, it won a contract for an amount of energy that meant its plant had to operate at an unattainable capacity factor. Also, it indexed the price offered 100 per cent to the US CPI, although its project was a CCGT plant. By January 2010 it had complied with the COD, but in February a tsunami left some power plants inoperable, raising the system's spot price above the Campanario contract price, which was in turn below the award price. The company continued to withdraw energy from the system to supply its clients, but in a couple of months became insolvent, leaving other generators with a virtually uncollectible claim.

[38] In December 2017, because of the lack of progress with the environmental permits, the company bought four existing plants that together add up to 750 MW and claimed that it had enough capacity to back up its contract. The Commission threatened to go to arbitration to invalidate the contract for a serious breach, but the parties finally reached an agreement whereby the company committed to installing two solar plants of 300 MW each between 2022 and 2023.

5. Lessons learned

5.1. Auction design

Chile has long experience of bidding for electricity supply contracts. Over time, successive governments have introduced numerous changes in the design and execution of the auctions. This section summarises this experience and analyses how regulatory changes have impacted the auctions' outcomes.Kruger and Eberhard (2018) caution that overly aggressive bidding may result in prices that are so low that successful bidders' proposals are unfeasible. Good auction design should therefore seek to achieve a balance between these two objectives. The Chilean experience provides some clues on striking a balance between cost-effectiveness and investment-effectiveness.

Higher qualification requirements for bidders and lower risks for awardees augment the likelihood that projects will achieve investment success. The downside of higher qualification conditions is that it may reduce cost-effectiveness by decreasing the number of potential participants and raising their costs. In turn, lowering risks for bidders should increase competition, but at the expense of transferring risk toother actors.

The system in which auctioneers first determine which bidders pass the financial and technical solvency prerequisites and then award contracts based exclusively on price bids has two advantages. First, competition on price only contributes to a more cost-effective outcome. Second, it does not require combining in one indicator aspects as different as the bid pricesand parameters of financial soundness and know-how.

The administrative requirements should ensure that those that comply with them have a good chance of successfully carrying out their projects. Notwithstanding the above, Chilean regulations provide for measures to deal with situations where a project is delayed or outright cancelled. Moreover, the auction terms, for example, contain provisions allowing an awardee facing construction problems to transfer the contract, with the Commission's approval, to another company, provided that the transferee takes over all the contractual obligations. Likewise, in the event of the insolvency of the awardee, the project financiers may auction the supply contract on condition that the new awardee assumes all contractual obligations.

However, the Commission has recently tightened the qualification conditions, probably in response to a rapid increase in the number of bidders. It seems prudent to increase the prerequisites, as with more competition, the possibility of project failure increases as the risk of winners' curse rises.An alternative to attract competitors to the auctions and have them bid lower prices is to reduce their risks. Chile's auction design introduced in 2005 aims to do precisely this by offering long-term contracts and award prices in US dollars adjusted according to costs. Regulated consumers absorb these risks as they are exposed to cost changes and exchange rate fluctuations over several years. However, consumers are generally in a better position to absorb these risks, as the electricity bill usually accounts for a smaller part of their expenses.[39]

The 2015 legal reform introduced several changes that further reduce the risks that awardees face. The changes allow for: (i) postponing COD or outright cancelling the contract; (ii) modifying contracts in the event of permanent changes in regulation or taxes that significantly

[39] Electricity accounts for 2.3 per cent of spending on the basket of goods and services representative of consumption in Chile's urban households. See https://www.ine.cl/estadisticas/economia/indices-de-precio-e-inflacion/indice-de-precios-al-consumidor.

increase awardees' costs; and (iii) replacing a project by another (2019 auction bases). The same reform introduced the possibility of calling for short-term tenders to cover the energy needs that may arise from unexpected events, including project cancellation.

On the other hand, as noted above, the Chilean auction design subjects bidders to two relevant risks: exposure to the spot price and demand risk. The former affects generators with non-dispatchable technologies, while it may benefit other generators.[40] The 2015 legal change intends to mitigate the spot price exposure risk by allowing the auctioning of energy in time blocks adjusted to the generation profiles of RE technologies. Table 9 summarises the results of all auctions that incorporated time blocks.

Table 9: Time block results by auction

Block type	Auction denomination bids reception date	Blocks	GWh auctioned	GWh awarded	Bidders with non-linked bids*	Successful bidders		Mean bid price	Minimum bid price	Mean award price
						Total	Non-linked bids			
Quarterly block	2017/01 October 2017	1 January–31 March	125	125	0	5	0	48.2	35.3	35.3
		1 April–30 June	125	125	0	5	0	48.2	35.3	35.3
		1 July–30 September	125	125	2	5	0	49.7	35.3	35.3
		1 October–31 December	125	125	2	5	0	49.7	35.3	35.3
Time block	2017/01 October 2017	23:59–07:59 (next day)	528	528	3	3	0	46.0	25.4	31.8
		08:00–17:59	778	778	2	3	0	38.1	21.5	31.6
		18:00–22:59	394	394	1	3	0	46.1	25.4	31.8
	2015/01 July 2016	23:59–07:59 (next day)	680	680	6 (11)	7	0	67.3	49.7	50.5
		08:00–17:59	1 000	1 000	23 (25)	6	1	42.3	29.1	41.9
		18:00–22:59	520	520	4 (8)	10	3	61.4	49.7	52.6
		24 hour block	10 164	10 164	-	13	-	61.9	31.8	47.6
	2015/02 October 2015	23:59–07:59 (next day)	370	370	3	3	0	88.2	78.9	82.1
		08:00–17:59	550	550	14	3	2	81.1	64.8	74.6
		18:00–22:59	280	280	3	3	0	92.8	78.9	85.1
	2013/03-2 December 2014	23:59–07:59 (next day)	250	50	1	2	0	110.2	110.2	110.2
		08:00–17:59	500	270	4	5	3	95.7	89.0	95.7
		18:00–22:59	250	15	1	2	0	117.0	111.1	117.0
		23:59–07:59 (next day)	250	75	2	1	0	102.2	100.6	100.6
		08:00–17:59	500	470	5	2	2	90.8	79.9	83.7
		18:00–22:59	250	45	2	1	0	102.0	100.6	100.6
		24 hour block	11 000	10 049	-	6	-	111.5	90.0	109.1

Source: Compiled by authors based on the database provided in https://www.licitacioneselectricas.cladd

Note: * Independent firms. Total firms that submitted bids in brackets.

In the auctions held from 2014 to 2016, a few bidders that submitted unlinked bids won contracts, and the average award prices differed between time blocks. However, in the 2017 auction, no unlinked bids won contracts, nor did average award prices differ between time blocks. This last result is a consequence of the award mechanism that selects the combination

[40] The 2005 auction design did not consider this risk because, in those years, no bidder backed its submissions with RE projects.

of offers that meets the full demand at the lowest cost. Although auction rules divide the year into time blocks, they allow bidders to link their bids submitted to different time blocks by conditioning them to be awarded all or none.

The benefits that the introduction of time blocks had for bidders that support their offers with variable RE projects, especially PV, are not at all evident. Firstly, bidders with unlinked offers can only win a contract if there are enough unlinked offers in the other time blocks at competitive prices or if the linked offers leave room in that time block. The results of the auctions show that these conditions are rarely met since unlinked bids that have won contracts are rare, with none in the last one.

The elimination of linked offers would avoid leaving out very competitive bids for specific time blocks, but it would be at best an imperfect solution. Bidders that used to submit linked bids in the previous auctions would probably make more aggressive price bids in the blocks where they expect to find more competition, and compensate them with higher price bids in the others, probably without significantly altering the average auction price results.

A more effective policy to reduce the risk of spot price exposure would have been to correct that design error in the electricity market that encourages the installation of inefficient back-up plants, which in Chile are oil-fired units. Table 10 shows the enormous variety in performance and, consequently, in operating costs of oil-fired power plants, with some consuming per unit up to 150 per cent more than the most efficient ones.

Table 10: Variable cost of oil-fired power plants

	CIS August 2012		CIS October 2015		NES January 2020	
	Specific consumption	Variable cost	Specific consumption	Variable cost	Specific consumption	Variable cost
	Ton/MWh	US$/MWh	Ton/MWh	US$/MWh	Ton/MWh	US$/MWh
Median value	0.26	282.61	0.26	162.4	0.25	189.5
Maximum	0.43	455.43	0.43	396.5	0.39	269.1
Minimum	0.17	169.24	0.17	83.5	0.16	98.2
Max/Min	2.5	2.7	2.5	4.7	2.4	2.7

Source: NEC, Fijación de precios de nudo de corto plazo, Informe Técnicos Definitivos

In 2012, the 25th lower percentile diesel plant had operating costs of US$265/MWh. It thus follows that the plant in the least efficient quartile determined the spot price at around 1 300 hours in the year with its value in some cases exceeding US$300/MWh (Figure 12). Moreover, exposure to high spot prices entails a financial risk for all bidders supporting their bid submissions with new projects. In fact, in case of a COD delay, they have to buy the energy on the spot market to supply their contracts.

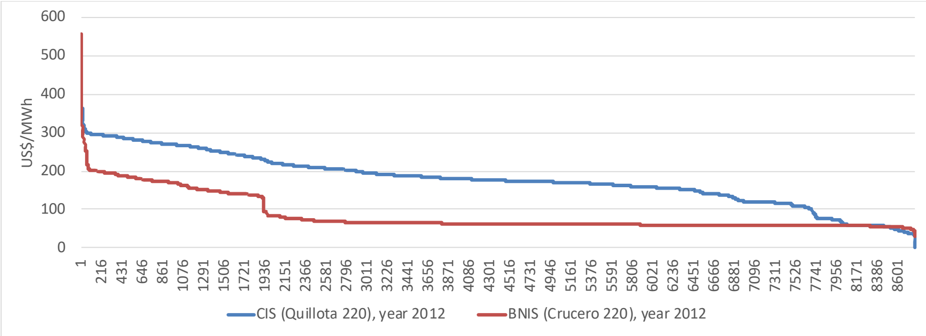

Figure 12: Hourly marginal cost of electricity duration curve, 2012
Source: Authors' compilation based on Coordinator (https://www.coordinador.cl/operacion/graficos/operacion-real/costo-marginal-real/), 2020

In recent years the value and the variability of the spot price have been reduced and, thereby, the risk associated with spot price exposure. Figure 12 shows the annual averages of the spot price for each hour of the day in the two systems in 2012. In the CIS, the hourly marginal cost decreased to less than one-third between 2012 and 2017. At the BNIS, the drop was also substantial but somewhat less. Annual averages may hide significant differences between days, but on average, the effects of exposure to the spot price should be less relevant, especially in 2017, when marginal costs were significantly lower.

5.2. Auction implementation

In Chile's auctions, the law obliges the off-takers, which are the distribution companies acting on behalf of their regulated clients, to make all their actions in the bidding process transparent and non-discriminatory, and gives the Commission a broad supervisory role. These conditions tend to guarantee the fairness of the processes, which is an attractive feature for potential bidders. Also, successive law changes have created an institutional framework to provide guarantees of impartiality in the application of electricity market rules to awardees. The system Coordinator is fully independent, and its decisions can be appealed to the Panel of Experts, reducing the risks of discriminatory treatment by the authorities, especially for new entrants.

6. Conclusion

Since 2015, bid prices in Chilean auctions have fallen considerably, in line with international RE cost trends and driven by fierce competition. Chile furthermore has a favourable business climate and low country risk. Off-takers (distribution companies) benefit from a low non-payment rate and a regulatory system that guarantees their rights, which in turn ensures the existence of a secure project revenue stream to suppliers. Besides, a well-developed financial system guarantees financing of projects for both incumbents and new entrants.

Until mid-2014, however, the auctions' outcomes were quite different. Competition was limited, bid prices were higher than both average production costs and bid prices in the early 2000s, matching the ceiling prices. These results were mainly due to public opposition and stricter environmental regulations that made the construction of new conventional baseload power plants – large hydroelectric plants and coal-fired – virtually impossible in the 2010s. Moreover, the generation costs with alternative technologies were higher than the auctions' ceiling prices, giving incumbent firms substantial market power.

A conclusion that follows is the need to anticipate and remove barriers to entry that would prevent effective competition, such as the availability of sites to build projects. In Chile, as in South Africa, awardees of auctions are responsible for the selection, preparation and securing of project sites, which is probably the right policy.[41] However, governments should take steps to ensure that there is a wide choice of sites, even if they are not responsible for selecting them.

In Chile, the Commission website provides information on the conditions for PV and wind generation throughout the territory. Also, the state, which owns a significant percentage of the land suitable for solar and wind power plants in the Atacama Desert (Insunza, 2015), has been auctioning site concessions for RE generation. On the other hand, there are unresolved issues related to site access. The mining statute takes precedence over any other economic activity in the country which, according to Insunza (2015), could become an obstacle for the financing of RE projects.

The availability of sites also relates to the expansion of the transmission grid to the areas with the best RE resources. These zones generally differ from those of conventional power plants. Chile suffered delays both in building local transmission lines to evacuate RE to the national transmission system (NTS) and in strengthening the NTS installations that transport RE to the consumption centres. The unanticipated rapid deployment of RE projects and the prolonged litigation in the processes of obtaining electrical easements delayed the commissioning of new transmission lines. This setback likely affected the participation of RE generators in the auctions. The introduction of the transmission systems for development poles in 2016 is an attempt to tackle this problem.

In the same vein, planners should anticipate that the system's costs will rise with the increasing penetration of variable RE generation. Indeed, there will be a higher need for ancillary services, in particular frequency control (primary, secondary and tertiary). It will be necessary to create a market for ancillary services to attract enough supply, the more complex issue being who pays for them. In Chile, regulatory changes from 2020 broadly provide for consumers to pay for these services rather than those who cause them. The need for ancillary services could fall away in the future if the cost of energy storage reduces enough to provide the system with flexibility, but it will still be necessary to determine who pays for storage services.

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[41] Available experience in the sub-Saharan region indicates that developer-led site selection in auctions of RE projects has been more successful than government-led approaches (Kruger et al., 2019).

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