Report D4.4-CL, July 2017

Auctions for Renewable Energy in Chile: Instruments and lessons learnt

Short about the project

Auctions for Renewable Energy Support: Effective use and efficient implementation options (AURES)

This project helps assessing the applicability of different auction types to renewable support under different market conditions. It also explores which auction types and design specifications suit particular requirements and policy goals in European countries. By establishing best practices and a knowledge sharing network, we contribute to informed policy decision-making and to the success of auction implementations across Europe.

Target-oriented analysis: Through analysis of empirical experiences, experiments and simulation, we will create a flexible policy support tool that supports policy makers in deciding on the applicability of auction types and certain design specifications for their specific situation.

Capacity building activities: We undertake specific implementation cases to derive best practices and trigger knowledge sharing amongst Member States. We strive to create a strong network with workshops, webinars, bilateral meetings, newsletters, a website that will serve as capacity building platform for both policy makers and market participants (including project developers, auctioneers,etc.). Wherever required, we can set up specific bilateral and multilateral meetings on specific auction auction issues and facilitate cooperation and knowledge sharing. Additionally, we offer sparring on specific implementation options, drawing from insights gained during the first phases of the project (empirical analysis of previous auctions in Europe and the world), conceptual and theoretical analysis on the applicability of specific designs in certain market conditions and for certain policy goals issues and facilitate cooperation and knowledge sharing. Additionally, we offer sparring on specific implementation options, drawing from insights gained during the first phases of the project (empirical analysis of previous auctions in Europe and the world), conceptual and theoretical analysis on the applicability of specific designs in certain market conditions and for certain policy goals.

Project consortium: eight renowned public institutions and private firms from five European countries and combines some of the leading energy policy experts in Europe, with an impressive track record of successful research and coordination projects.

The report contributes to the first and second of three tasks in work package 4 of the AURES project:

T4.1 Providing a characterisation of the different auctions

T4.2 Making an assessment of auctions and case-specific lessons learnt

T4.3 Interpreting and summarising the general lessons learnt and resulting and thereby outline specific recommendations

For further information please contact Pablo del Río pablo.delrio@csic.es

Report D4.4-CL, July 2017

Authors: Pablo del Río (CSIC)

Reviewed by: Ana Amazo (Ecofys)

AURES; a coordination and support action of the EU Horizon 2020 program, grant number 646172.

Table of contents

1. Characteristics of the electricity auction in Chile

With a population of 17.95 million (2015) and a GDP of $240.8 billion 2015, Chile has been one of Latin America's fastest-growing economies over the past decade. However, following the 2010-2012 economic expansion, GDP growth fell to 1.9% in 2014 and 2.3% in 2015, as a result of the slowdown in the mining sector due to the end of the investment cycle, and the decline in copper prices and private consumption. The unemployment rate also rose slightly, from 5.7% in July 2013 to 5.8% in January 2016 (World Bank 2016). Chile has sharply reduced poverty rates and increased shared prosperity in recent years. However, its per capita income (US$ 21,980 in 2014) is still far below the average of US$ 41,035 for OECD countries. Additionally, structural changes to drive increases in productivity and improve access to and quality of social services should be implemented for a more inclusive growth. Energy deficits and dependence on copper exports continue to be a source of vulnerability (World Bank 2016).

Chile's shape - 4,300 km long and on average 175 km wide - has given it a hugely varied climate. This ranges from the world's driest desert - the Atacama - in the north, through a Mediterranean climate in the centre, to a snow-prone Alpine climate in the south, with glaciers, fjords and lakes (BBC 2016).

Electricity system features

The Chilean electric power grid is organized in four independent systems, i.e., they are not integrated. From north to south, they are the Northern Interconnected System (SING), the Central Interconnected System (SIC), and two medium size systems in the extreme southern region (Aysén and Magallanes) (Ministerio de Energía 2015). The energy-intensive nature of the copper industry creates substantial correlation with power demand growth. In 2015, the copper industry consumed 23TWh, which represented 33% of the total power generated in the country that year. Mining operations are located in the northern part of the country, mostly serviced by the SING system. Although most of the mining industry's electricity demand occurs in the SING area, two-thirds of the country's total installed capacity (21GW) are in the SIC system (Climatescope 2016).

Chile was one of the first countries in the world to deregulate and privatize its electricity sector, with the enactment of the Electricity Law of 1982. According to the law, the generation segment is demarcated as a competitive market with private entities having the freedom to follow market forces while making investment decisions and setting prices, whereas transmission and distribution are recognized as monopolistic activities and therefore companies operating in these segments have regulated tariffs with set measures for investment requirements. The concepts of regulated and unregulated customers were also introduced. The Electricity Law also introduced a spot market with marginal pricing that offers exclusive access to generators, and opened the power sector to private investment. Hence, between 1983 and 1989, a wave of privatization of state-owned electricity utilities occurred. The Electricity Law has been amended several times after the country witnessed electricity shortages (Roy 2016).

The Chilean government has also announced plans for a transmission line between Mejillones and Copiapó that should be completed by 2017. This transmission line will unify the SING and SIC, accounting for almost 99 percent of Chile's grid. In addition, in January 2016, Chile's Congress approved restructuring of the transmission system to improve overall efficiency, including the establishment of a new system operator (U.S. Department of Commerce 2016).

Renewable energy in Chile

Electricity generation in Chile has been based on two main energy sources, coal and hydro, with a share of 35% and 31%, respectively, followed by gas (16%)(2014 data, IEA 2014). RES-E currently accounts for 15% of electricity generation in the country, as a result of substantial increases in the installed capacity and shares of wind and PV (Tables 1 and 2).

Table 1. RES-E accumulated capacity under operation in Chile (MW)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Geothermal											48
Wind	22	22	82	178	200	200	290	736	911	1424	1424
Solar thermoelectric							39	39	39	39	39
Bioenergy	124	173	175	175	207	345	395	472	477	481	481
PV						3	12	222	865	1611	1840
Small hydro	249	281	302	330	379	404	459	472	546	600	615

Source: Elaborated by the Chilean Renewable Energy Association (ACERA) on the basis of information published by the National Energy Commission (CNE).

Table 2. Share of RES-E in electricity generation in Chile (%).

	Small hydro	Bioenergy	Wind	PV	Geothermal	Total RES-E
2012	1.81	2.41	0.59	0		4.81
2013	2.03	3.01	0.79	0.01		5.85
2014	1.96	3.37	2.14	0.65		8.13
2015	2.17	3.31	2.74	1.91		10.12
2016	2.72	3.08	4.05	5.28		15.13
2017*	2.21	3.51	4.63	4.93	0.04	15.32

* As of April 2017. Source: Elaborated by the Chilean Renewable Energy Association (ACERA) on the basis of information published by the National Energy Commission (CNE).

According to the U.S. Department of Commerce (2016), few countries have as much renewable energy potential, and as much need for renewable energy as Chile. The Atacama Desert in Northern Chile is widely considered the world's best solar resource. Similarly, strong wind, geothermal, and hydropower resources exist across the country.

Through its National Energy Strategy, the government of Chile has committed to the long-term diversification of the country's energy matrix and to creating the conditions to make energy more competitive, cleaner and more secure. The strategy prioritizes the incorporation of non-conventional renewable electricity (NCRE) sources and the development of electricity. NCRE sources defined by Chilean law include biomass, geothermal, small hydro plants (< 20 MW), solar, tidal and wind[1]. In 2016, the Chilean government released the Energy 2050 Roadmap, which lays out a vision for the electricity and energy sector until 2050. The Renewable Energy Law 20257 in 2008 set a renewable energy target of 5% for 2010-2014. This target would increase by 0.5% per annum since 2015 up to 10% in 2024. Later, in 2013, Law 20698 raised the target to 20%, to be met by 2025.[2]

The Transmission Law 20936 in 2016 set a new electricity transmission system and created an independent coordinator of the National Electricity System Agency (Roy 2016). In January 2016, President Michelle Bachelet signed Chile's new energy strategy, "Energy 2050" which set a target of generating at least 70 percent of the country's electricity from renewables by 2050.

Auctions are used both by the private and the public sector in Chile. Since 2005 (Law 20018), electricity distribution companies are required to source power for regulated markets through public non-discriminatory auctions. Although renewable were included, the regime of supply excluded NCRE sources in practical terms, according to one interviewee. In 2013, Law 20/25 introduced a public auction system specifically intended to ensure that the existing NCRE quota obligation would be met. The new system allows for RES-E auctions on years when it is anticipated that the renewable electricity quota will not be fulfilled. The auctions would be technology neutral and based exclusively on price (IRENA 2015a). These auctions have never taken place, as the yearly NCRE quota has always been met in excess.

On January 2015, the Chilean congress approved a new law (Law 20805) that modified the tender process to supply energy to distribution companies. This law established that the auction should be conducted 5 years before the actual supply started, transferred the management of the auction from the distribution companies to the National Energy Commission (CNE), included a mechanism that allows an awarded company to delay the start of supply under specific circumstances and extended the length of the contracts to 20 years. The changes aimed to increase the level of competition in the auction.

[1] The terms NCRE and RES-E are used interchangeably throughout this report.

[2] In addition, this Law encouraged NCRE technologies to sign energy contracts with distribution companies (Cruzate 2017).

The CNE organized the electricity supply auction (Licitación de Suministro Eléctrico 2015/01), offering 12430 GWh/year, which will meet the electricity needs of clients regulated by the SIC and SING electricity systems for 20 years since 2021.

Table 3. Characterisation of auctions for energy supply in Chile

Characteristics	**Description**
Country characteristics	See text
Market characteristics	See text
Name of auction scheme	Licitación Suministro 1/2015. Full name: "Licitación Pública Nacional e Internacional para el Suministro de Potencia y Energía Eléctrica para abastecer los consumos de clientes sometidos a regulación de precios (Licitación de Suministro 2015/01)"
Objectives	-To provide electricity to cover the public service consumption of customers subject to price regulation. -To cut electricity bills for consumers.
Contracting authority	The distribution companies are the off-takers.
Main features	-Lowest total present cost of supply (price-only), multi-item, static auctions. A *levelised price* is used for purposes of bid ordering. It is calculated on the basis of the bid price, several indexes and projections of fuel prices. -Technology-neutral auctions (both conventional and RES)
Year of introduction	Electricity auctions have been adopted for a long time. This case study analyses the 2016 auction, performed under the new 20805 law.
Technology focus and differentiation	No differentiation. Technology-neutral auctions. Developers offer to provide a certain amount of capacity. They must state the type of power plant that they are planning to build, but this does not affect the evaluation of the offer.
Lead time before auction	Call: May 29th 2015, Presentation of bids: July 27th 2016. Publication of results: August 17th 2016
Min./max. size of project	No

Characteristics	Description
What is auctioned?	-Energy. -The auction is organised per Supply Block. A Supply Block is defined as “the maximum supply commitment that can be assumed by the bidder in its bid and represents the total amount of energy to be awarded by the bidders in the current auction for the corresponding period. Each Supply Block included in the current auction will be divided into Sub-Blocks for the purpose of submission of bids by bidders”. Each Block includes a Base component and a Variable component (the latter represents 10% of the Base component). The Sub-Blocks have the same size (same quantity of annual energy).
Budgetary expenditures per auction and per year	Not available
Frequency of auctions	Not previously set schedule. They have taken place every year or every two years. Each year the CNE issues a report that shows the long-term demand curve and identifies the upcoming auctions.
Volume of the tender	12430 GWh, divided into 5 supply blocks: **-Supply Block nº1**. Volume: 3080 GWh. Divided into 250 Sub-Blocks. It will supply electricity from 1 January 2021 until 31December 2040. **-Supply Block nº2-A**. Volume: 680 GWh. It will exclusively supply electricity consumption between 00:00 and 07:59 and between 23:00 and 23:59. **-Supply Block nº2-B**. Volume: 1000 GWh. It will exclusively supply electricity consumption between 08:00 and 17:59. **-Supply Block nº2-C**. Volume: 520 GWh. It will exclusively supply electricity consumption between 18:00 and 22:59. Supply Blocks nº2-A, 2-B and 2-C are divided each into 50 Sub-Blocks. They will supply electricity from 1 January 2021 until 31 December 2040. **-Supply Block nº3**. . Volume: 7150 GWh. Divided into 350 Sub-Blocks. It will supply electricity from 1 January 2022 until 31 December 2041.

Characteristics	Description
	The bids for block 1 could be “conditioned” to a bid in block 3, i.e., the block 3 bid would only be valid if the block 1 bid was not awarded. Furthermore, non-awarded bids in block 1 could participate in block 2 as a “restricted bid”. A “restricted bid” means that bids in blocks 2-A, 2-B and 2-C could be considered together, i.e., they might not be awarded separately if the bidder decides so. This means that electricity bidding in block 1 could participate for the whole amount of electricity being auctioned (12430 GWh/year), whereas a bid in block 2-B, for example, could only participate for 1000 GWh/year (ACERA 2016a).
Auction design elements	See Table 4

1.1 Design elements for the assessment of the auction

Table 4. Design elements in Chile’s auction

Design elements	
Single- or multiple-item auctions	Multiple-item (blocks)
Auction procedure	Static auctions.
Pricing rules	Pay-as-bid.
Ceiling price	Yes. Disclosed after the bidders send their bids but before the publication of the winning bids. Under the previous Law 20805, the ceiling price was disclosed before the bids were submitted. There is a ”reserve margin” (margen de reserva): The bids above the ceiling price but less than 2.5% above that price are allowed to modify their offer price.
Qualification criteria	-The bidder’s credit rating (published by a reputable company) must meet minimal requirements. Bidders have to provide a report on their credit rating, elaborated by any of the entities included in Annex 3 of the tender documents (Feller-Rate, Moody’s, Standard and Poor’s, Fitch Ratings, Humphreys Ltda and ICR Chile Ltda).

	- A specific-purpose company must be formed in order to participate in the auction (if the bidder is not a limited company, it must choose a limited company in Chile as legal form). -Information that has to be provided by the bidders in order to back their bids. Among others: - Identification of existing and projected generation sources (name, type and installed capacity). - Name of the owner company of each generation source. - Location (existing or expected). - Estimated date of entry into operations. - Primary fuel and origin of the fuel. - Connection point (current or projected). - Physical features of the power lines. - Own production of energy in the last 5 years. - Copy of the balance sheets and consolidated income statements in the three years before the year of bid submission. - Commercial and financial background of the bidder. -Any generator who wins a contract must be a registered company in Chile and her bond rating must be BB+ or higher. Alternatively, if the generator is not yet registered in Chile, it must pledge a bid bond to back its bid. This bond is for 100 Unidades de Fomento (around 3700€) per GWh bid on for the last year of the contract. For example, a contract for 3,000 GWh per year (around one-fourth of total consumption in Chile's Metropolitan Region), worth around US$150 million each year at the mean bid price in the auction, requires a guarantee of US$12 million, or 1% of the contract's present value or US$0.50/MWh. The amount of the bid bond (Garantía de Seriedad de la Propuesta) will be UF 100 per GWh (i.e., 3700€/GWh) offered by the bidder. The Unidad de Fomento (UF) is a unit of account which is adjusted according to Chile's inflation. 1 UF = $ 26.561,42 Pesos Chilenos; € 1 Euro = $ 722,44 Pesos Chilenos; 1UF = 37€. -Second, in order to cover possible third-party damages during construction or operation of the new power plant, the winning generator must purchase insurance to cover damages of up to US$3 million. It must also purchase an additional US$3 million in coverage for catastrophic risks during plant construction or subsequent operation. -Lastly, the generator must pledge a bond to guarantee contract performance. A performance bond for UF 300 per GWh bid on for the last year of the contract (about 11100€/GWh) needs to be provided. The performance bond is redeemed if the generator does not meet its supply commitments. Alternatively, the

	generator can take out an insurance policy for the same amount (UF 300 per GWh bid) (Muñoz and Galetovic 2017).
Penalties	Contract termination, confiscation of bid bonds.
Monitoring of realisation progress	The CNE can audit the progress in the construction of new power plants.
Exceptions from requirements for small plants/developers?	No
Support auctioned	No specific RES-E support is auctioned, instead generators compete for Power Purchase Agreements (PPAs) through technology-neutral electricity auctions.
Transferability of support right	Yes
Other	-The auctioned contracts are denominated in US dollars and can be adjusted periodically to the United States' Consumer Price Index (US CPI). The terms and conditions of the bidding procedure provide a polynomial with several indexes, including a fuel price index. Bidders may build their own indexation formula, and decide on their own weights. Bids for RES-E were 100% indexed to the US CPI, instead of being indexed to fuel prices. It should be taken into account that the bid price is not the only element being assessed. A LEC is calculated in order to compare bids which are indexed to different indexes. Those bids being indexed to fuel (i.e., not to the CPI), are more expensive, since fuel prices are expected to grow more than the US CPI. - 20-year contracts. - New as well as existing plants can participate. - The auction terms and conditions also allow start-up of the project backing the contract to be postponed for up to two years, paying a fine of UF10 per month of delay for each GWh contracted the last year (only in case of causes attributable to the bidder). - Within the first three years of signing the contract, and on the grounds of third-party liability, the generator can request abandonment of contract by paying UF 360 per GWh that should have been supplied over the last year.

2. Evaluation criteria for the assessment of auction schemes for RES-E

Actor variety and social acceptability

There were many participants in the auction: 84 bidders and 22 winning bids from 9 countries, including Ireland, Germany, Spain and Italy (table 5). Local firms had a very small share in the auction (Besalco and AELA Energía, only 98GWh out of the 12430 GWh being awarded).

Table 5. Amount of generation awarded (GWh) per auction winner.

Auction winners (companies)	Country	Amount of generation awarded (GWh)
Mainstream	Ireland	3366
ENDESA	Italy/Spain	5918
WPD	Germany	786.8
Ibereólica	Spain	1034.8
ACCIONA	Spain	506
OPDE	Spain	176
Cox Energy	Spain	264
Solarpack	Spain	280
Besalco	Chile	10.4
AELA Energía	Chile	88
TOTAL		12430

Source: Own elaboration.

According to our calculations, based on official data, RES-E accounts for 52% of the energy being auctioned. Wind accounts for most of this percentage (Table 6). This calculation matches exactly the one by ACERA (2016a). However, other sources provide different data on the results. According to the Chilean Ministry of Energy, 2/3 of the volume awarded comes from wind and solar technologies (Ministerio de Energía 2016), while according to IRENA (2017), 4400 GWh were awarded to wind (35.4%) and 580 GWh were awarded to solar (4.6%). The reason for this dicrepancy might be that, as suggested by Bloomberg (2016a) and Thompson and Millán (2016) in Chile's power auctions, developers offer to provide a certain amount of capacity at a specific price, without saying exactly what type of power plant they're planning to build (or by mentioning a combination of them). According to one interviewee, bidders have to inform about the type of project but they can change one project by another afterwards.

Table 6. Winning bids (total and per technology)

	GWh	%
Solar*	411.9	3.3
Wind*	5913.6	47.5
Other**	6104.4	49.1
TOTAL	12430	100

Source: Own elaboration. * It is assumed that half of the 264GWh awarded to Cox Energy are for wind generation and the other half is for PV generation (Cox Energy was awarded wind/PV). ** The category ”Other” includes coal, diesel, natural gas and hydro.

The auction was organised per block. Block 1 (3,080 GWh/Year | 24 hr. Block) was won mainly by wind projects (94.7 %). Block 2-A (680 GWh/Year | Night Block) was won only by wind projects (100 %). Block 2-B (1,000 GWh/Year | Solar Block) was won by solar and wind projects (28 % solar). Block 2-C (520 GWh/Year | Peaking Block) won mainly by wind (98 %) and Block 3 (7,150 GWh/Year | 24 hr. Block) was won by a mix of existing conventional and renewable plants (Fraunhofer Chile 2016).

Block 3 received bids for the greatest amount of energy (probably because it was the second option for the energy not awarded in Block 1), followed by Block 1 (because the bids not awarded in Block 1 would participate in Block 2 and, thus, have more chances to be awarded)(ACERA 2016a).

According to ACERA (2016a), the hourly Blocks (which were introduced in 2014) have been an important factor of the success of the auction in Chile. The possibility to bid during certain hours has allowed the participation of variable RES-E. In turn, this participation has been partly responsible for the high level of competition and low bid prices in the last auction. However, in this auction, only 17.7% of the energy was auctioned in hourly blocks (2200 GWh/year). Only 28% of such amount (616GWh) was awarded to bids in these blocks. The rest of energy being awarded in Block 2 came from bids not awarded in Block 1. The fact that the energy not awarded in Block 1 would be transferred to Block 2, together with the fine for the energy not covered in the awarding process, would discourage offering bids in the hourly blocks (ACERA 2016a). The disincentive to use the hourly blocks has led to a relatively low penetration of PV, despite the fact that the PV bid prices are lower than those of wind (ACERA 2016a).

Mostly utility-scale projects will be deployed. The Ministry of Energy argues that new actors will be incorporated in the electricity sector as a result of the auction (Ministerio de Energía 2016). Indeed, conventional energy companies like Colbún and AES Gener, which formerly dominated the market, could not compete and were not awarded in the auction (Energy Advisor 2016). According to Thompson and Millán (2016), half of the auctioned energy will be provided by existing capacity, i.e., not only new capacity participates.

Policy effectiveness (effectiveness of auctions)

Effectiveness in the AURES project has been defined as the realization rate of projects. However, in line with del Río and Linares (2014) and IRENA (2013) a so-called “a priori effectiveness” has also been considered, i.e., the amount of volume offered in the auction which is being contracted[3]. There was a 100% ”a priori” effectiveness, since all the energy auctioned in all blocks totalling 12430 GWh was awarded.

Regarding effectiveness in terms of realisation rate, it is too early to judge. However, many stakeholders have commented on foreseen realisation rates. Some are skeptical in this regard, given the low prices of some of the winning bids for these projects. Some reasons are given for such skepticism:

- The very low prices have raised doubts about their economic feasibility (Cruzate 2017). They make it difficult to obtain finance, questioning the bankability of some of the awarded projects (Manancourt 2016). Investors are required to risk their equity and charge for it, i.e., those that are awarded contracts must be obligated to back-up their supply with sufficient equity as soon as they make the commitment (Muñoz and Galetovic 2017). According to Bloomberg (2016b), some of the companies being awarded in the auction are struggling to get financing, given the high level of leverage. However, there are also reports from some of the winning companies stating that it won’t be difficult for them to obtain finance (Bloomberg 2016b, Millán 2017). Manancourt (2016) argues that there is a belief that costs for many of the projects will come down thanks to technological advancements. This is obviously risky if those cost reductions do not materialize in the future. It is very difficult to know if this has been a widespread practice, however.
- There have been some delays in the previous auction, which were awarded at higher (although still aggressive) bid prices. According to Millán (2016), USAID (2016) and Bloomberg (2016b), only one of five companies that won contracts at an earlier auction in 2015 would be ready to supply the electricity as pledged. According to one interviewee, this was due to the participation of bidders who were outsiders to the electricity business, with little experience in this sector and actors with an speculative purpose.
- Aging transmission infrastructure and congestion. Some doubt that these projects can be completed, given Chile’s aging transmission infrastructure and congestion (Energy Advisor 2016, p.3). According to Cruzate (2017, p.6), the RES-E sector is eager to see the end of the connection infrastructures, which are currently under construction. There are currently congestion in some nodes of the electricity system, which are leading to limitations in the evacuation capacity of several projects. However, one of the interviewees mentioned that this would be true for contracts with COD in the next few years, but for supply starting by 2022 or 2023, this problem should be solved by the new transmission law that was recently approved. There are concerns that the grid in Chile is ill-equipped to accommodate intermittent RES-E generation (Norton 2017, p.16, Roy 2016). Indeed, solar power firms and some wind developers are already experiencing curtailment of their energy production in the north central regions of Chile

[3] IRENA (2013) defines effectiveness (success rate) as the percentage of volume awarded compared to volume auctioned.

(Editoron 2016). According to USAID (2016), investors are betting on new transmission, which is in the process of being built, that will interconnect the Northern regions (where many RES-E plants will probably be located) and the central regions (where most of the consumers live)(USAID 2016, Millán 2017). However, the transmission projects are already experiencing delays, which may eventually stretch to a year (Millán 2017). However, the projects will have to provide electricity in 2021, and the infrastructure will probably be built by then (Editoron 2016). According to article 83 of the of the General Law on Electricity Services (Ley General de Servicios Energéticos), modified by Law 20936 (Electricity Transmission Law), the Ministry of Energy will have to develop a long-term energy planning process every 5 years.

- Guarantees pledged are rather insufficient according to Muñoz and Galetovic (2017) and one interviewee. Indeed, some prequalification requirements will be made more stringent in the next auction in 2017 (higher bid bonds)(Muñoz and Galetovic 2016, El Periódico de la Energía 2017). In January 2017, the Minister of Energy announced that in the next auction there will be an increase in the gurantees from 400 UF/GWh to 800 UF/GWh (from 14800 to 29600€/GWh)(EnergyNews 2017). This could suggest that they were not stringent enough in the current auction and that the government might be concerned about effectiveness. Prequalifications are regarded as a main driver to ensure that winning projects are built. However, one interviewee strongly disagreed with this view, since the awarded companies have delivered the bonds.
- Some of the particular clauses in the PPA with the distributors have also contributed to some uncertainty in the sector and, in particular, the non-existence of a purchasing commitment (take-or-pay), which leads to the generator assuming the demand risk (Cruzate 2017).

On the other hand, some factors make others be more optimistic about the effectiveness of the auction:

- The auction for regulated electricity consumers was reformed and small and medium blocks of energy and time blocks of energy were established. Generators could then bid into slots which correspond to times during the day and the night, which is widely credited with opening up these auctions to solar and wind projects (Roselund 2016, Azzopardi 2014, Energy Advisor 2016). Before, companies should be able to provide electricity at any hour in the week, which left out solar and wind electricity (El Mostrador 2016). In the new auction, RES could compete now and, indeed, won in most blocks.
- The period to build the projects and produce electricity was extended to 5 years (2021). This facilitates that the projects are built in time and will also facilitate financing (Energy Advisor 2016).
- Although the low prices in the auction are highlighted, it should be taken into account that electricity prices in Chile are comparatively high, far above other those in other countries in the region (U.S. Department of Commerce 2016). This is arguably one of the reasons behind the success of RES (Norton 2016, U.S. Department of Commerce 2016).
- Better grid conditions. Chile also recently passed a law involving a major upheaval of its transmission system that had been widely regarded as a critical hindrance to the deployment of renewables and the power sector at large (see above). In April 2015, President Bachelet confirmed the government's commitment to its energy plan for the unification of Chile's two electricity grids, the central one (SIC)

and the Northern one (SING), by signing an official decree (Norton 2016, p.16). The new power lines connecting the northern and central grids are mentioned by many authors as reducing the costs and risks for investors and increasing the opportunities for RES-E projects, ensuring that power generated from renewable energy projects located in remote regions of the country is supplied to population centres (Editoron 2016, Dezem and Millán 2016, Bloomberg 2016b, Mahatrapa 2016, Millán 2016, Muñoz and Galetovic 2017). The main transmission lines are expected to begin operation in Q4 2017 and in 2018, alleviating the congestion problems (Cruzate 2017).

- Roy (2016) mentions other factors, which positively influence the effectiveness and efficiency of the auction: High renewable energy generation potential, little or no land use regulation (leading to ease in development of projects), highest credit rating in Latin America (due to macroeconomic stability and integration with global capital markets), attractive destination for FDI (due to simple foreign investing process and low taxes), no minimum local content requirement for companies incorporating in Chile and direct PPAs with the consumer, which increase bankability of projects. For Energy Advisor (2016), the success of the auction was also the result of the implementation of a target of 20 percent of non-conventional renewable energy by 2025.

Finally, it should be mentioned that the relevance of the total amount auctioned (12430 GWh) is high. It is expected to represent about 1/3 of electricity consumption since 2021 in the SIC and SING systems (El Mostrador 2016). Furthermore, this is one of the largest electricity auction in Chile in the last 12 years (table 7).

Table 7. Volumes in electricity auctions in Chile 2006-2016 (GWh).

Auction year	Volumes
2006	13206
2007	7500
2008	8756
2010	2200
2012	1172
2013	3900
2014	12705
2015	1200
2016	12430

Source: Ríos (2016).

Static efficiency or cost effectiveness (including transaction and administrative costs)

The prices in the Chile auction for electricity technologies in general and for RES in particular are reported to be one of the lowest in the world. Many sources stress the record-breaking low of $29.1/MWh for a solar plant to $73/MWh for a wind plant, as well as the average (and median) bid prices for the winners of 47.5

US$/MWh. This average bid price is 40% lower than in the previous auction (79.3$/MWh)(ACERA 2016a). The table below shows the average, maximum and minimum prices of the winning bids in each block.

Table 8. Average maximum and minimum prices of winning bids in each block (US$/MWh).

	Prices of winning bids		
Blocks	Average	Maximum	Minimum
1	40.418	43.116	38.077
2-A	50.545	64.000	43.116
2-B	41.892	47.472	29.100
2-C	52.637	73.000	43.116
3	50.792	55.440	44.053
Total	47.552	73.000	29.100

Source: Elaborated by the Chilean Renewable Energy Association (ACERA) on the basis of information published by the National Energy Commission (CNE).

The aforementioned average bid price was also the lowest average price ever obtained in an electricity auction in Chile (table 9) and it is also outstanding given the large volume of electricity auctioned and contracted.

Table 9. Average electricity prices in electricity auctions in Chile 2006-2016 ($/MWh).

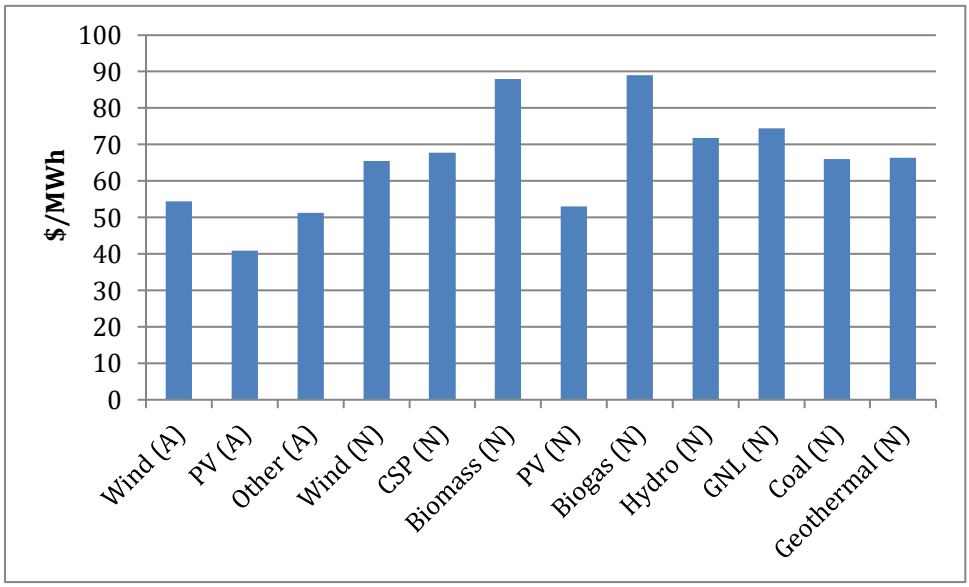
Auction year	Average Prices
2006	53.1
2007	64.4
2008	103.8
2010	90.3
2012	131.4
2013	128.4
2014	108.4
2015	79.3
2016	47.5

Source: Ríos (2016).

It is also often emphasized that renewables were more competitive than conventional energy technologies and won a large share of contracts (IRENA 2017). Chile is deploying large volumes of PV and wind without any subsidies or government incentives.

The following figure shows the average bid prices of the projects being awarded (A) and non-awarded (N). It can be observed that PV and wind have offered very competitive bids in the auctions, much lower than the conventional counterparts. A surprising result is that the average price of non-awarded PV is slightly below the price of wind being awarded (see above). An interesting finding is that CSP and geothermal have average bid prices below natural gas and similar to coal. Biogas and biomass offered the highest bids. Note that bids which combine different technologies have not been included in this figure. See Annex I for further details.

Figure 1. Average bid prices awarded (A) vs. not awarded (N).



Source: Elaborated by the Chilean Renewable Energy Association (ACERA) on the basis of information published by the National Energy Commission (CNE).

The degree of competition in the auction was very high. According to Energy Advisor (2016) and El Mostrador (2016), the 84 different companies which participated offered 85000 GWh of energy, almost seven times the volume auctioned. However, acording to our calculations, the amounts offered added up to 119000 GWh, i.e., more than 9 times the volume auctioned.

There are some plausible reasons behind those low prices and high competition levels:

- Large wind and solar resources and high capacity factors. The capacity factors in Chile are on average 29% for PV (IRENA 2017) and 30% for wind (ACERA 2016b). Compared to countries in America where auctions have been organised recently for RES-E (e.g., Peru and Mexico), those capacity factors are probably on average higher regarding solar and lower regarding wind (ACERA 2016b).

- The auctioned contracts are denominated in US dollars and can be adjusted periodically according to the US CPI, which implies that developers are shielded from both interest rate risks and inflation risks (IRENA 2015b, IRENA 2017).
- The aforementioned better grid conditions. This has attracted more participants to the auction (Energy Advisor 2016, p.3) and prompted developers to bid low (Bloomberg 2016a). Transmission Law transforms the way transmission is paid for: consumers and not generators pay 100% of the cost (Roy 2016).
- Long-term contracts available. Many bidders are thought to have been drawn by the long-term contracts available. 20-year terms allow companies to offer their financial backers steady long-term income (Manancourt 2016).
- Longer deadline for building the projects than before (5 years, instead of months, as it was previously the case). More time to build the power plants facilitates financing of projects. Longer deadlines are one of the reasons behind greater competition for some authors. Chile's government inserted a five-year period in 2014 with the explicit aim of increasing competition (Manancourt 2016, El Mostrador 2016).
- Participation in the auction was encouraged by the government, which organised an international road show trying to convince firms in the U.S., Europe, Brazil and Asia to participate in the auction (El Mostrador 2016, Manancourt 2016).

According to the interviews, in addition to the long duration of contracts and the longer deadlines to build the projects, some design features of the scheme contributed to reduce the risks for RES-E investments and level the playing field for RES-E, making those investments more attractive, while simultaneously increasing competition. These include the existence of hourly blocks (which contributed to more bids being submitted, i.e., to more competition), the possibility that the awarded bidder could postpone supplying energy due to "justified causes" (which is relevant for e.g. CSP), measures of the CNE to share the risk with the bidder and the possibility to revise the support (price) in case of legal, sectoral or fiscal changes, in order to reduce the risk premium. Regarding the later, both interviewees referred to the possibility to revise the support (price) in case the CO2 tax (currently at the level of 5€/tCO2) would increase to very high levels. However, this also raises distributional issues as well as concerns regarding the consistency and coordination of the energy policies in the country.

Some of the factors aforementioned by Roy (2016), which positively influenced effectiveness, also had a likely positive effect on the efficiency of the auction and its low prices, including little or no land use regulation, the highest credit rating in Latin America and no minimum local participation requirement for companies registered in Chile.

Note that, before the Law 20805, the ceiling price was disclosed before bid submission. According to one interviewee, non-disclosure was adopted in order to avoid anchoring, i.e., firms which knew such price adjusted their bids marginally close to it.

Dynamic efficiency

Regarding the dynamic efficiency of the scheme, the impacts are non-negligible regarding the expected penetration of new wind and solar projects (5530 GWh according to our own calculations). This means almost three times as much generation from solar and wind as was the case in 2014. It is true, however, that other renewable energy technologies (geothermal, CSP) have not been awarded and, thus, technological diversity is modest in that sense. The impact on the local supply chain is likely to be modest, and circumscribed to installation activities, given that there are few local manufacturing firms and that foreign firms overwhelmingly won contracts in the auction. It is interesting to note that, although CSP and geothermal have not been awarded, their bid prices were on average lower than those for coal and natural gas (see above).

Compatibility with market principles and integration

Given the technological neutrality of the auction, with RES competing face-to-face with conventional electricity technologies, the auction has been allegedly compatible with market principles. On the other hand, the compatibility with market integration can also be deemed very high, since RES have to contribute to electricity system services in the same manner as other technologies. Contracts are signed on a bilateral basis between the off-takers (distribution companies) and the winners in the auction. The end users market is based on bilateral financial contracts, not physical contracts.

Distributional effects & minimization of support costs

The aforementioned low prices and the reductions in electricity prices which have been achieved in this auction with respect to previous auctions benefit consumers. The winning bids slashed electricity costs to $47.60 per megawatt hour, significantly lower than the original market expectations of around $80 per megawatt hour (Energy Advisor 2016, Manancourt 2016). According to the government, electricity bills will experience reductions of between 15% and 20% (El Mostrador 2016). ACERA (2016a) provides an interesting analysis of the savings for the consumer as a result of RES-E bids in the auction. It estimates the savings taking into account the total amount of awarded energy (valued at the average awarded price) and, then, a scenario of the bidding process was simulated in which no RES-E bids had been presented. The difference between the costs in the two scenarios (1863 million $) provides an estimate of the cost savings for the final consumer. Obviously, the price for the final consumer won't drop automatically. The resulting PPAs start in 2021 and older PPAs with higher prices still are and will be in force (Energy Advisor 2016).

3. Lessons learnt: key best practices and pitfalls identified

- In some parts of the world, under specific conditions, RES-E can already compete successfully with conventional energy sources for electricity generation in technology-neutral auctions.
- Although wind and solar PV can be deployed successfully without subsidies in some places, providing hourly segments in technology-neutral auctions may be needed to further encourage the uptake of RES-E.
- In addition to the hourly blocks, some design features of the scheme contributed to reduce the risks for RES-E investments and level the playing field for RES-E, making those investments more attractive, while simultaneously increasing competition: the long deadlines to build the projects, the long contract duration, the possibility to postpone the energy supply due to justified causes, measures of the CNE to share the risk with the bidder and the possibility to revise the price in the event of legal, sectoral or fiscal changes.

References

- *ACERA (2016a). Resultados del proceso de Licitación 2015/01*
- *ACERA (2016b). Análisis comparativo de condiciones y características de las Licitaciones de Energía en Perú, México y Chile. Asociación Chilena de Energías Renovables. June 6th 2016.*
- *Azzopardi, T. (2014). Renewables takes 20% in Chilean power auction. Windpower Monthly17 December 2014*
- *BBC (2016). Chile country profile. http://www.bbc.com/news/world-latin-america-19357497*
- *Bloomberg (2016a). Solar Sold in Chile at Lowest Ever, Half Price of Coal Bloomberg http://www.bloomberg.com/news/articles/20160819/solarsellsinchileforcheapesteverathalfthepriceofcoal1/4. 23/8/2016*
- *Bloomberg (2016b). ¿La revolución de energía renovable en Chile está en peligro? El Comercio 20 DE OCTUBRE DEL 2016 | 12:19*
- *Climatescope (2016). Chile http://global-climatescope.org/en/country/chile/#/details*
- Cruzate, J. (2017). El mercado de Energías Renovables No Convencionales (ERNC) en Chile: un sector de éxito, incertidumbres y futuros. Cuadernos de Energía 52, 5-8
- *Del Río, P., Linares, P. (2014). Back to the future? Rethinking auctions for renewable electricity support.Renewable and Sustainable Energy Reviews 35, 42-56.*
- *Dezem, V., Millán, L. (2016). Chile's Largest Power Auction Gets 84 Bids; Seen Slashing Prices. Bloomberg July 27th 2017.*

- *Editoron (2016). Chile enacts its largest ever power tender. July 30, 2016In: Education & Technology News.*
- *El Mostrador (2016). Irrupción de renovables en licitación eléctrica logra que precios se desplomen a mínimos históricos y Pacheco celebra. 17 de agosto 2016.*
- *El Periódico de la Energía (2017). Chile endurece las reglas de las subastas para la licitación de 2017 por los bajos precios. 27/1/2017.*
- *Energy Advisor (2016). What are the effects of Chile's Largest Energy Auction?. September 2, 2016.*
- *EnergyNews (2017). Tercera subasta eléctrica en Chile por 4.200 GW anuales Publicado el 31/01/2017.*
- *Fraunhofer Chile (2016). Large Scale PV: The Chilean Experience Intersolar South Sao Paulo. Brazil, August 2016. Fraunhofer Chile Research – Center for Solar Energy Technology | FCR-CSET*
- *IEA (2014). Country energy statistics.*
- *IRENA (2013). Renewable energy auctions in developing countries.*
- *IRENA (2015a). Renewable Energy Policy Brief. Chile.*
- *IRENA (2015b). Renewable energy auctions. A guide to design.*
- *IRENA (2017). Renewable energy auctions. Analysing 2016. Executive summary.*
- *Mahapatra (2016). New Low Solar Price Record Set In Chile — 2.91¢ Per kWh! August 18th, 2016 by Saurabh Mahapatra cleantechnica.*
- *Manancourt, V. (2016). Winners of Chile's record electricity auction may not be bankable, say lawyers. Monday, 19 September 2016 by Vincent Manancourt. Cariola Diez Perez Cotapos Abogados.*
- *Millán, L. (2016). Renewable Miracle Is Real Deal as Chile Counters Doomsayersby Laura Millan Lombrana September 29th 2016. Bloomberg. https://www.bloomberg.com/news/articles/2016-09-29/renewable-miracle-is-the-real-deal-as-chile-counters-doomsayers*
- *Millán, L. (2017), Company that offered cheapest solar sees prices falling more. Bloomberg, March 30th 2017*
- *Ministerio de Energía (2015). CHILEAN EXPERIENCE IN DEVELOPING ELECTRIC POWER INFRASTRUCTURE 1st Workshop for APEC Initiative for Enhancing Quality of Electric Power Infrastructure August 26th - 27th , 2015*
- *Ministerio de Energía (2016). Histórica Licitación de Suministro Eléctrico 17 de Agosto de 2016. http://www.energia.gob.cl/tema-de-interes/historica-licitacion-de-0*
- *Muñoz and Galetovic (2017) Energy Auctions in Chile: Guarantees and Leverage. http://www.brevesdeenergia.com/blog/posts/energy-auctions-in-chile-guarantees-and-leverage/*
- *Norton Rose Fulbright (2017). Renewable energy in Latin America: Peru http://www.nortonrosefulbright.com/knowledge/publications/134777/renewable-energy-in-latin-america-peru*
- *Ríos, A. (2016). Análisis de las subastas renovables del año 2016 13/11/2016*
- *Roselund, C. (2016). Solar wins substantial contracts in Chile's energy supply auction. October 28 2015, PV Magazine.*

- *Roy, P. (2016). Market Information Report: Chile. MaRS Market Insights. Ontario, Canada.*
- *Thompson and Millán (2016). Chile Sees Surge in Wind Power, Rattles Incumbents by Eduardo Thomson, Laura Millan Lombrana. August 23rd 2016. Bloomberg.*
- *U.S. AID (2016). Technical note. The basics of competition & auctions for renewable energy.*
- *U.S. Department of Commerce (2016). 2016 Top Markets Report Renewable Energy Country Case Study Chile. International Trade Administration.*
- *World Bank (2016). County overview: Chile. http://www.worldbank.org/en/country/chile/overview*

ANNEX I

Awarded bids. Amounts (GWh) and average bid prices.

	GWh	Average bids ($/MWh)
Wind	5913.6	54.5
PV	411.9	40.9
Other	6104.4	51.2
TOTAL AWARDED	12429.9	

Source: Elaborated by the Chilean Renewable Energy Association (ACERA) on the basis of information published by the National Energy Commission (CNE).

Non-awarded bids. Amounts (GWh) and average bid prices.

	GWh	Average bids ($/MWh)
Wind	15375	65.5
CSP	8360	67.8
Biomass	660	87.9
PV	4597	53.1
Biogas	308	89
Hydro	9577	71.8
GNL	26756	74.5
Coal	15103	66
Geothermal	242	66.4
Wind, Hydro and PV	176	64.9
Wind, GNL and PV	988	79.8
Diesel and wind	88	72.5
Diesel and hydro	88	79.3
Pump and PV	3652	66.9
Coal diesel, GNL and hydro	19448	56.4
Wind PV	858	59.5
Hydro PV	75	92.9
TOTAL NOT AWARDED	106351	

Source: Elaborated by the Chilean Renewable Energy Association (ACERA) on the basis of information published by the National Energy Commission (CNE).