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Retail Electricity Market Liberalization: An Overview of International Experience and Effects on the Chilean Regulated Tariff

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Abstract: The Chilean government is looking to liberalize the retail electricity market to increase competitiveness and reduce the price of electricity for residential and small/medium commercial customers. Under this context, the article aims to enrich the legislative debate by providing an overview of the international experience of the electricity market liberalization that started in the early 1990s and presents forecasting for the regulated Chilean price until 2034, considering the current tenders and the price stabilization mechanism. In addition, multiple simulations are developed to measure the market effect of retail liberalization on regulated customers. In this regard, the results suggest a significant regulated price increase from 2022 to 2032, produced mainly by the stabilization mechanism, which overshadows the low prices obtained in recent renewable generation supply tenders. However, if the retail market is liberalized, the simulation indicates that regulated customers could save between 15% and 20% on their electricity bills.

Keywords: electricity market; retailing; liberalization; regulatory framework

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1. Introduction

Electricity markets have been under constant change and evolution since their large-scale operation in big cities started at the beginning of the twentieth century [1]. In the early stage, the power systems were governed in a vertical and monopolized structure, usually managed by a state-owned or private company; however, the constant electricity demand growth made the vertical structure unsustainable, triggering governments to start a liberalization and unbundling process in order to promote private investment and increase the power system's efficiency and the market's competition [2]. Thus, in the early 1990s, many countries worldwide began separating the vertical structure into private segments and monopoly assets as reported in [3–7]. Specifically, the generation and supplier stages were open to free competition, and the transmission and distribution networks were declared natural monopolies under different mechanisms. However, after thirty years of electricity market liberalization, the European Union and many countries worldwide are facing the problem that the retail markets are not reflecting a significant electricity price reduction because there still exists high market concentration and political barriers, which makes the entry of new competitors difficult [8].

In 2016, Chile began the discussion to reform the retail electricity sector because, despite having started unbundling the electricity market in the early 1980s, Chile did not touch the retail market [9] and is currently facing a lack of market competition and high electricity price issues. In this regard, the discussion has been focused on whether liberalizing the retail market will effectively reduce the price of electricity. Palacios et al. [10] indicate that customer welfare would increase under partial or complete retail market liberalization. However, international experience shows that high competition and price reduction are not direct from liberalization. For example, the work by Green in [11] suggested that under a liberalized market context, mergers are generally the easiest way to make a company larger and concentrate its power, instead of promoting competitiveness. A similar issue is commented on by Kumar et al. [12] for the Indian wholesale electricity market, where the concentration of firms after liberalization explains part of the increasing electricity prices. The work conducted by Tishler in [13] for the Israeli case reaches the same conclusion, adding that some extra incentives must mitigate the negative profits. In Great Britain, Pollitt et al. [14] demonstrated that a competitive retail market for electricity is possible. However, it also demonstrates how vulnerable that market is to political interference affecting free competition. Likewise, the work developed by Hellmer et al. [15] in Nordic countries suggests that increasing the number of small producers will not affect the competition significantly if there is a dominant firm in the market, stressing that it is not just the number of competitors, it is also the size of the largest companies. The European Commission also finds the same problem related to increasing energy prices for final customers after liberalization markets, arguing that a significant supplier concentration does not allow the transfer of the wholesale price to the retail market as reported in [2].

Therefore, considering the discussion above that retail market liberalization does not directly ensure high competitiveness and low electricity prices, the Chilean government has postponed the discussion in the Senate until the benefits to end users are well established. However, resolving this retail market reform is one of the authority's priorities for 2023 [16]. In this context, this paper seeks to contribute to the current Chilean retail electricity market discussion through a mathematical simulation of the tariff savings under a free tariff scheme and provide an overview of the last thirty years of international experience to identify critical factors to avoid market concentration in the liberalization process. Thus, the main contributions are described as follows:

- An approximation forecast is presented for the regulated customers' tariff for the next 15 years, based on tenders awarded and the current mechanisms to stabilize the customers' price.
- The savings generated by the eventual migration of residential and commercial customers from a regulated tariff to a free tariff scheme is measured, considering the power required to access them.
- An overview of the international experience in the electricity market liberalization process is presented, considering three axes: the unbundling steps, data management policy, and renewable energy sources incentives.

The rest of the paper is outlined as follows. Section 2 presents the international experiences overview of the electricity market liberalization, stressing the most significant milestones in the process for eight countries. Then, Section 3 discusses and presents different research articles that assess the expected results of the retail market liberalization process in terms of the pricing effect and the competitiveness market level. The simulation results considering a free tariff scheme for three Chilean cities and different residential and commercial segments are presented in Section 4. Finally, Section 5 sets out the conclusions and suggestions.

2. Overview of International Experience

This section presents a general review of the international liberalization electricity market experience in Spain, Denmark, Germany, Italy, Portugal, France, the United Kingdom, and the United States. The criteria for choosing the reference countries have been based on the nominal GDP; their influence on Chilean economic policy, such as the UK and the USA; their deployment and rollout of smart meters; and the available data related to the milestones of electricity market liberalization. However, throughout the text, other specific experiences of other countries are mentioned to contextualize some regional situations. The data reviewed have been grouped into three axes: unbundling, smart meters/data management, and renewable energy sources. Thus, the unbundling axis covers the main milestones for the wholesale and retail electricity market opening and the access/operation of the transmission and distribution networks. The smart meter rollout has been considered a relevant dimension in the competition in the retail segment because its massive deployment allows suppliers to offer different tariffs and products, increasing the investment incentive and competition. Finally, the political instruments to promote the electricity generated from renewable resources have been considered by their effect on the wholesale and retail market prices. In order to frame the temporal scope of the liberalization process, at the end of this section, Figure 1 shows a summary timeline of the three axes commented above since the early 1990s, including the Chilean experience.

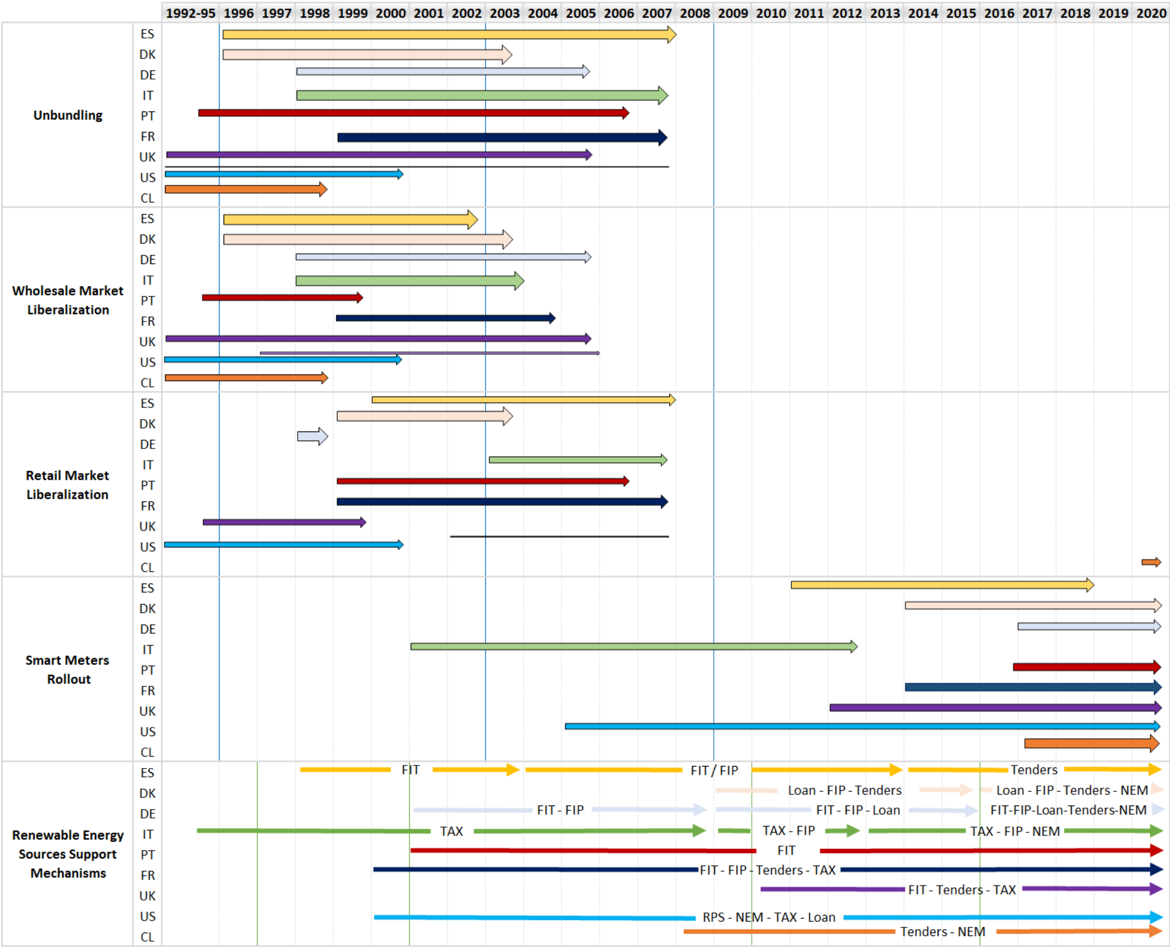


Figure 1. Electricity market liberalization timeline for Spain (ES), Denmark (DK), Germany (DE), Italy (IT), Portugal (PT), France (FR), the United Kingdom (UK), the USA (US), and Chile (CL).

2.1. Unbundling

As a consequence of the first energy package promoted by the Europe Union (EU), countries such as Spain started the liberalization process in 1997 with the Electric Sector Law [17], defining consumption and generation as a competition regimen and transmission and distribution as regulated activities according to Acquila-natale et al. [18]. Likewise, Law [19] established the wholesale and retail markets and defined suppliers as intermediaries between producers and consumers. Similarly, in Denmark, the first law for liberalizing the electricity market was presented in 1996, where consumers with demands over 100 GWh could have electricity contracts with any supplier, and in 2003, this was extended to every consumer, as reported in [20]. In Italy, the government opened up the generation, importation, exportation, purchase, and sale of electricity in 1999 with the Bersani Decree [21]. Then, in 2004, the transmission and distribution systems were assigned under a concession scheme as natural monopolies. Non-residential customers could choose their provider, while for the residential sector, it was not until 2007 that they could choose, as indicated by Stagnaro et al. [22]. Likewise, the French electricity sector's liberalization started with the EU at the end of the 1990s. However, unbundling of the integrated company EDF (French Electricity) took place only in 2004, separating generation, retail, transmission, and distribution [23]. The retail competition started in 1999 for large companies and was expanded to smaller clients and residential customers in 2007, as reported by Bauby et al. [24].

On the other hand, Portugal foresaw the EU directive and released their energy sector reform in 1995, which established the bases of the electric system's organization regarding generation, distribution, and transmission matters (DL 182/1995), as indicated by Ferreira et al. [25]. Supply liberalization began with the DL 36/2004, where the consumers of MV/HV could choose their supplier, and the DL 192/2004, which extended this choice to the consumers of LV and was fully implemented in 2006, according to [26]. Likewise, through the Energy Industry Act, the German energy market was seamlessly and wholly liberalized in 1998 for all segments, regions, and clients of the electricity sector [27]. In addition, generation and suppliers were defined under a free market, allowing customers to choose their suppliers, as reported by Rodionova et al. [28]. However, Germany was the only EU country where the grid access conditions were negotiated between three private associations (BDI, VDEW, and VIK) [29]. This negotiation blocked competition, and it was not until 2005 (supported by the second package of the EU) that the negotiations for grid access were deleted, and it was regulated with standards, rules, and contracts (Amendment of the Energy Industry Act).

Outside the current EU countries, the case of the UK and the USA have been reviewed to draw relevant experiences that started before the energy packages promoted by the EU. For example, through the Electricity Act (1989), the British government began restructuring and privatizing the electricity market in 1990 (England and Wales), establishing the wholesale electricity market (the Pool) under a uniform-price auction and day-ahead spot market. However, the market design was highly criticized due to the lack of a mechanism to promote competition and the significant market power concentration in the National Power company, as reported by Woo et al. [30]. Thus, an entire competition was introduced into Britain's electricity retail market in 1999, with domestic and industrial customers able to select and readily change their electricity supplier, as reported by Kirsti et al. [31].

Across the Atlantic, the restructuring of the electricity market began in the United States in 1992 with the National Energy Policy Act (EPAct), followed by four years where the Federal Energy Regulatory Commission established the market rules, ending the process with Order 888 in 1996, as mentioned by Lee et al. [32]. In this process, the wholesale market was reformed, opening transmission lines and creating independent system operators and regional transmission organizations, as reported by Wakiyama et al. [33]. Likewise, in these years, the retail market allowed non-utility companies to buy electricity in the wholesale market and sell the energy to retail consumers for different prices and options, as in Joskow et al. [34]. Thus, at the end of 1996, the liberalized market rules were set. However, the reforms were not mandatory, and every state was free to choose if it followed the new market framework. From 1996 to 2000, twenty-three states implemented the legislation, California being the first state to liberalize the retail electricity market in 1996, as mentioned by Lee et al. [32].

The above international experience highlights the importance of a transmission and distribution system that is well connected, safe, and guarantees access to every competitor that wants to participate in the electricity market. Specifically, the German case shows how restricted access to the grid promotes market concentration in a few companies and prevents free competition, even under a liberalization retail market scheme. Likewise, it is inferred that the wholesale and retail market opening occurred almost simultaneously between the 1990s and the first decade of the 2000s. However, it took between seven and ten years for residential and small commercial customers to access free tariffs, despite having a liberalized market. Even so, the expected results, specifically for the retail market, have not been satisfactory since there are still low competition levels in the supplier segment (appropriately addressed in Section 3).

Long before any of the countries mentioned above, Chile started the liberalization process in 1982 with the fourth general law of electrical services (DFL 1/1982 LGSE, as mentioned in [35]). Thus, the electric system was separated into generation, transmission, and distribution systems, defining transmission and distribution as natural monopolies, while generation was established under a competition regimen. Consequently, the government created the wholesale and spot market, leaving the supplier role for distribution companies and awarding the transmission and distribution system's management to private companies under tendering, as indicated by Serra in [36]. In contrast with the international experience, Chile did not liberalize the retail market and did not create the suppliers' entity, delaying a full libralization of the electricity market, concentrating the market power in five companies, and preventing new competitors from entering into the electricity market, as reported by Palacios et al. [10].

2.2. Smart Meters

Initially, the EU promoted the large-scale rollout of smart energy meters (SM) with Directive 2006/32/EC, as reported in [37], to offer precise details in the consumption bill of end-users and to increase the networks' stability, efficiency, and security. Three years later, the third energy package established a target smart meter penetration above 80% by 2020. Thus, countries with an advanced large-scale rollout program have declared: operational savings in remote meter readings around 5.42–7.85%, as indicated in [38]; reduced non-technical losses for distribution system operators DSOs; increased energy efficiency; and bill reduction for end-users.

In the European context, Italy was the first country of the member states to deploy smart meters in 2001, such that in 2011, more than 80% of the consumers had a smart device implemented for metering. However, the installed devices did not fulfill the EU's requirements (2012), and after the Legislative Decree 102/2014, the second deployment of smart meters of the second generation started. Sweden was another pioneer country to start early with the installations of SMs in 2003, followed by Finland and Malta in 2009. In the Spanish case, the first law related to smart metering was RD 1110/2007 (modified in IET/290/2012), and DSOs performed the deployment between 2011 and 2018, where the customers payed the implementation cost monthly through a rent tariff. Most European countries started between 2012 and 2014, such as Austria, the UK, Slovenia, Estonia, Romania, Greece, the Netherlands, Denmark, and France, as reported in [39].

On the other hand, some countries have delayed their SM deployment despite possessing a legal framework since 2012, as in the Portugal case reported by Chawla et al. [40] (2025 expected to end the rollout), or in Germany, where the Smart Meter Operation Act was enacted recently in 2017 and the end of the large-scale rollout is still undefined. In almost all European countries, the smart meter deployment corresponds to the DSOs, except in the UK, where the suppliers are responsible and in Germany, where it is the Meter Point Operator's responsibility.

Leaving the European countries, in the US, the Energy Policy Act of 2005 (which amends the Public Utility Regulatory Policy Act of 1978) established a national policy of "federal encouragement of demand response devices," setting the standards for smart metering; however, it was not mandatory, and every state was free to adopt it, as mentioned by Rose in [41]. In 2007, the Energy Independent and Security Act encouraged the states to advance in the rollout of smart meters. In 2020, 75% (115 million) of US households have a smart meter, as indicated by Cooper et al. [42].

In contrast to most European countries, Chile started deploying smart meters in 2016. However, the government and distributors' lousy information campaign prevented a correct acceptance from citizens, leaving the entire deployment process stalled. In addition, the lack of distribution market competition could be considered a third responsible party for the failed deployment. Because, in the Chilean case, the market concentration is high, the users only perceive an electricity bill increase due to the payment of the new device, and they do not receive offers from other competitors.

2.3. Renewable Energy Sources

In the renewable energy field, the EU has also played a relevant role in introducing different directives, as reported by Schope in [43–46] over the last 20 years to improve energy efficiency, reduce greenhouse gas emissions, and set energy transition goals according to [47]. In this regard, European countries have implemented different mechanisms depending on the technology and the power production to promote investments, initiatives, and research to achieve the renewable energy sources (RES) target penetration of 32% for 2030, established by the current directive RED II (Directive 2018/2001), as reported in [48]. The most common mechanisms used are Feed-in Tariffs (FIT), Feed-in Premiums (FIP), Green certificates (GCs), Investment grants, Tendering schemes, Net-metering (NEM), and Excise tax returns.

In the Spanish case, the RD 2818/1998 established a FIT scheme for electricity from RES (RES-E) and CHP, modified with the Renewable Energy Act in 2004, where an FIP started running to support renewable technologies, as mentioned by Ciarreta et al. [49]. However, due to unexpected results, the government abolished the tariff system (RD-19/2013), and in 2014, a new electricity sector act (20/2013) established a new scheme based on the call of tender. Unlike Spain, Italy possesses an NEM, FIP, and two tax regulations systems. In 1993, Italy promoted electricity from solar and wind technologies, reducing 10% of the value-added tax for deliveries or investment-related costs. The second tax regulation came into force in 2008 (L 244/07), allowing municipalities to reduce the real estate tax of buildings equipped with RES technologies, and the energy producers could sell the energy to GSE (Electricity Service Operator) or in the market through an FIP scheme. Some years later (Delibera 570/2012), an NEM started to operate, allowing self-consumption. In Portugal, the DL 339-C/2001 modified the previous DL 189/88–DL 168/99 to include the rules for electricity production from RES under an FIT scheme, which has been upgraded through several DLs, without including new mechanisms. On the other hand, the Danish government released in January 2009 its Decree on the Promotion of Renewable Energy Act (amended Act 1009/2018), which established: loan guarantees for local wind and solar initiatives, FIPs for plant operators, and a tender scheme for new wind and solar installations. In addition, in 2016, the Decree for Net-Metering (BEK 999/2016) came into force and promoted self-consumption.

In the German case, many mechanisms are available to promote electricity from renewable resources, and the first FIT/FIP systems were approved in 2001 (amended with the EEG 2017). The second is a focus on loans (2009—General rules for investment loans) focusing on offshore/onshore wind farms, photovoltaic installations, geothermal generation, storage systems, hydrogen vehicles, and innovative RES pilot projects. The last two schemes that came into force were tendering and net-metering (EEG 2017), which started to operate in 2017, promoting significant investment and self-consumption, respectively. In the UK, the FIT mechanism was introduced in 2012 for small-scale generation systems with a capacity below 5 MW in addition to the carbon price floor tax, which levied fossil-based fuel, in 2013. The first tenders based on contracts for difference were awarded in 2014, and since 2017, it is the only mechanism to support renewable investments over 5 MW.

The primary policy mechanism used in most states (36) of the US is the Renewable Portfolio Standard (RPS), which establishes that a share of the power generation or sales must come from a renewable resource. However, the RPS is supported by other instruments such as net metering (43 states), interconnection standards (41), tax incentives (47), public benefits funds (18), and energy efficiency resources standards (18), as reported by Carley in [50]. In the South American region, Brazil has promoted electricity generation from renewable resources such as wind power, biomass, and small hydro plants by creating the Alternative Source Incentive Program (PROINFA) in 2002. The mechanisms include FITs, tendering through auctions, and net metering for distributed generation, which was adopted in 2012 [51]. Thus, Brazil increased its installed wind farm capacity by 4755 MW from 2011 to 2014 [52]. Likewise, in Chile, the government has promoted renewable technologies since 2008 through a tenders scheme (ERNC Law), which forces generation companies to inject electricity from non-conventional renewable energy sources. Likewise, the Chilean government has also used the net-metering scheme to promote the penetration of distributed energy resources at residential and commercial levels through the net-billing mechanisms since 2012 and modified in 2017, such as in Italy, the US, Germany, and Denmark.

3. Retail Market Competitiveness and Pricing

This section presents the assessments developed in different research articles and European reports about how the milestones commented on in the previous section have affected electricity prices and the retail market's competitiveness, i.e., has the electricity market's liberalization had the desired effect in terms of price and competitiveness?

3.1. Liberalization Effects on Pricing

After 30 years of electricity market liberalization, the question emerges: What has been its effect on the retail market's electricity price? At the beginning of the second decade, the European Commission (EC) was concerned about the rising trend in electricity prices for households, even though the member states already possessed, from 2007, a fully liberalized wholesale and retail market. Thus, in 2014, the EC released its first report, as reported in [2], related to the energy prices' trends; the significant highlights are summarized as follows:

- The taxes/levies and network costs are the main drives that explain the higher prices. Specifically, despite a decreasing trend in wholesale electricity price, which was more significant in countries with high distributed energy sources penetrations, this trend is not reflected in the retail prices due to different network tariff regulations, fragmenting internal market, taxes, levies, network distribution systems, and uncoordinated national energy policies.
- There are still high market concentration levels and low switching rates, which is translated into lower retail market competitiveness.
- A regulated retail price tends to be detrimental to competition in the retail markets, discouraging investment entry and new competitors. Thus, the energy price increased 4% (above inflation) every year from 2008 to 2012; the network cost went up 18.5% from 2008 to 2012; and the taxes/levies have risen by 36%.

Figure 2 shows the electricity prices for households from 2008 to 2019, where the trend described above and the upgrade until 2019 reflect the significant effects of the taxes/levies on final pricing. Since 2014, the price without taxes, including energy and network costs, has remained stable; however, the trend increases continuously when the taxes are included.

Other studies external to the EC have addressed the same issue through different dynamic models to explain a possible positive correlation between electricity market liberalization and households' final electricity prices. In addition, the effect of renewable technologies are also included in the correlation analysis. Thus, the work reported by Iimura et al. [53] concluded that the electricity market reforms in seven developed countries are positively correlated with lower household prices, whilst a high renewable penetration is not statistically significant. As reported by Silva et al. [54] and Hyland in [55], it was also concluded that the liberalization process has achieved the expected effects; however, they stress that a regulated price prejudices the reforms' impact. The research presented by Moreno et al. [56] indicates that electricity market reforms have decreased the retail price of electricity; however, this has not meant an increase in competitiveness. In addition, it is commented that the effects of RES on the retail market have been lower than expected because, on the one hand, a high RES penetration in the wholesale market decreases the price, and on the other hand, part of the increase taxes are to finance public RES support schemes. Therefore, the net effects of a decrease in the wholesale price and increased retail price are limited. The last effect commented by Moreno et al. [56] matches with the last European Commission report in [57], which indicates that taxes/levies should decrease for 2030 due to the decreasing price of RES technologies and increasing carbon price, which would imply that the final prices for households must be lower.

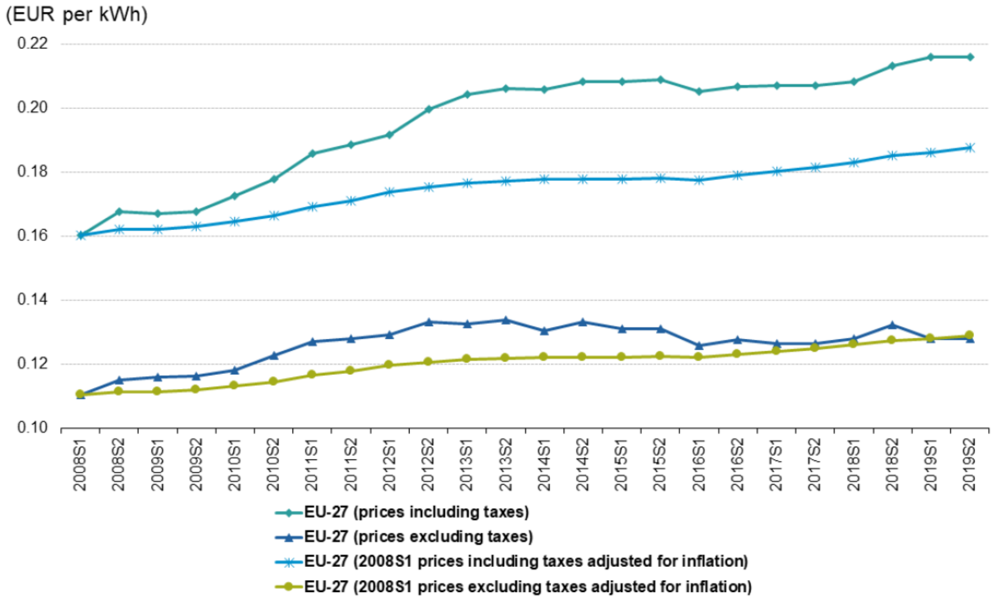


Figure 2. European pricing trends from 2008 to 2019. Source: CEER Monitoring report on the Performance of European Retail Market in 2018 [58].

3.2. Competitiveness

Over the last thirty years of legislative reforms on the electricity markets, part of the market structure and dynamics have been modified, affecting how the customers choose their electricity suppliers and the variety of products and services available. However, the transition from an integrated vertically system to a liberalized retail market has taken more time than expected. In 2019, the Council of European Energy Regulators (CEER) published a report to assess every member states' retail market performance under three layers: market structure, switching rates, and price regulations.

The CEER report in [58] addresses the first layers through different indicators to measure the competitiveness of market levels such as the CR3 and HHI. The CR refers to the concentration ratio associated with the three most prominent nationwide suppliers, and the HHI is the most accurate indicator reported in [58], which assesses the degree of market concentration, such that an index greater than 2000 means a high-level concentration. In addition, the barriers to enter/exit the market and the number of suppliers are also considered a reference of competitiveness since a higher number of suppliers means higher offers of variety and, therefore, more choices for the end customers. Thus, according to [59], European countries with more suppliers are Spain, with 232, and Poland, with 146. However, the average concentration rate of the three most significant suppliers in Europe has decreased by only 9% in 6 years (from 2013 to 2018), managing 63.5% of the retail electricity market.

The second layer, which is also another competitiveness indicator, refers to the customer switching rates. The customer's willingness to change their suppliers is usually associated with their empowerment, the ease of the switching process between providers, their awareness about their rights, and the products/services available on the market. However, notwithstanding EU packages and regulation reforms in most MS, to promote the easy movement of customers between providers, there are still many households that keep their headline provider, which is the case of France (9.8%), Italy (9.1%), Denmark (5.1%), and Greece (4.5%), all of which had a less than 10% switching rate reported in 2018. On the other hand, Norway leads the European countries with a 21.4% switching rate, followed by Great Britain with 19.1%, Portugal (15.9%), Spain (10.4%), and Germany (10.2%).

The CEER's reasons to justify a low switching rate are regulated prices, taxes, low monetary incentives, and a lack of trust in new providers. In this sense, a market with regulated prices is another key factor (third layer) to promote competitiveness, according to the CEER. Indeed, the Clean Energy for All Europeans package stipulates that the price for end-users in retail electricity markets must be "free from government intervention". Moreover, other special tariffs should be transient or used only for exceptional cases. Currently, most MSs are in a transition stage to a not regulated price or possess some price-regulated grade, which is the case of GB, FR, ES, PT, and IT, where price regulation or special tariffs for vulnerable customers coexist.

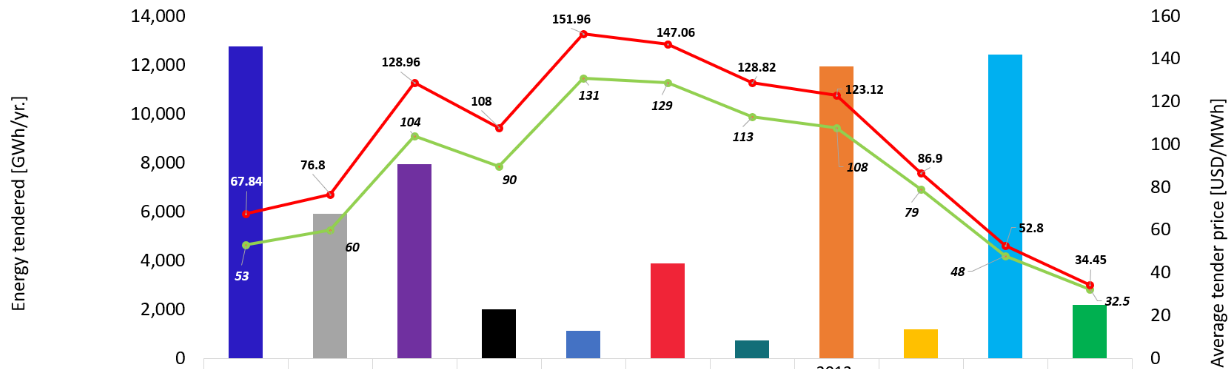
The reports and articles mentioned above stress the regulated tariffs, the high concentration of the power market by a few companies, and customer switching rates as the main factors that have prevented the desired effect of liberalization of the electricity market. Moreover, the Chilean government must be careful when discussing distribution reform in their parliament. Specifically, Chile does not have a liberalized retail market, concentrating the market power in five distribution companies, which implies almost zero entry of new competitors, lower market competition, and lower customer switching rates. In addition, the regulated tariff must be considered an essential factor to promote the entry of new competitors, decrease the market concentration, and increase competitiveness and customer switching rates, as indicated by the European experiences in this matter.

3.3. Chilean Retail Electricity Tariff (Fee)

Around 70% of the energy bill breakdown for customers under a regulated tariff scheme, excluding taxes, corresponds to energy consumption; the remaining 30% comprises distribution and transmission charges (20% and 10%, respectively). On the other hand, the energy price for the regulated scheme is modified semi-annually (January and July) by the National Energy Commission (CNE) through the Average Knot Prices (PNP), which reflect the suppliers' contracts established in the tendering process between generation and distribution companies for a period of around 15 to 20 years (Law 20.018 from 2010).

Figure 3 shows a summary of tenders for the last 15 years, where the bars indicate the energy amount tendered, the green line is the average base price awarded, and the red line represents the current prices, including the American Consumer Price Index. A high awarded price difference between the contracts implies higher prices for end-users due to the PNP fixed by the CNE considering the weighted average of active contracts to date. The price tender reduction between 2013-03/2 and 2015-01 is a product of the tenders based on renewable resources; however, due to the PNP mechanism, a lower price in the last tender is not reflected in the final price because the price of the tender 2013-03/2 increases the average. Thus, the current active contracts related to 2013-03/2 and 2015-01 with their respective current prices (red line) of 123.12 USD/MWh and 52.8 USD/MWh make Chilean customers receive a high energy price in their bills (consider that 1 GWh = 1.000 MWh; 1 MWh = 1.000 kWh).

In December 2019, due to the sustained growth in regulated tariffs, the Stabilized Price to Regulated Customer (PEC) mechanism is established by the government in Law 21.185 to freeze the regulated electricity price until 2023. Thus, the PEC mechanism replaces the current price (PNP) perceived by the customers with a lower and stable price, whose difference (PNP minus PEC) is reflected in a balance favoring the generating companies, which must be lower than USD 1350 MM, i.e., the customers' aggregate debt between 2019 and 2023 must be lower than USD 1350 MM. However, due to a lower price reducing the generators' incomes, the CNE established a factor, informed semi-annually, that indicates the percentage by which generators must reduce their collection.



	2006-1	2006-2	2008-1	2010-1	2012-1	2013-01	2013-03	2013-03/2	2015-02	2015-01	2017-01
Energy [GWh/año]	12766	5925	7960	2000	1149	3900	750	11955	1200	12430	2200
Price [USD/MWh]	53	60	104	90	131	129	113	108	79	48	32.5
Price to 2021 [USD/MWh]	67.84	76.8	128.96	108	151.96	147.06	128.82	123.12	86.9	52.8	34.45

Figure 3. Tender summary for regulated customers to date. Based on the data in [60].

By 2024, the PEC mechanism will disappear, and regulated customers shall return the accumulated balance to the generators through an additional charge in their electricity bill calculated in the future semi-annual tariff decrees. Law 21.185 indicates that the total balance must be reimbursed to generation companies by December 2027; thus, CNE must consider this in the semi-annual fixes and transfer an amount to the regulated client that cancels out the balance accumulated.

4. Materials and Methods

This section presents the algorithms used to estimate the energy price stabilization mechanisms and project the different tariffs for regulated customers, consolidating multiple criteria and variables in an automated way. Thus, Figure 4 presents the algorithms used to measure the stabilization mechanisms' effect on the regulated tariffs, and Figure 5 shows the algorithm to assess the tariff for every region of the country. In this regard, the regulated tariff must follow the following structure:

$$\text{Final fee (tariff)} : 70\%\ \text{Energy price} + 10\%\ \text{transmission cost} + 20\%\ \text{distribution cost}. \quad (1)$$

Thus, the energy price is estimated, considering more than 5000 contracts between generation and distribution companies [60], forecasting the biannual electricity demand for every region of the country and the accumulated biannual dollar price. In addition, the energy price estimation includes the accumulated effect of possible outstanding balances from previous semesters, and since there is an energy price stabilization mechanism, it is necessary to verify the conditions reported by H. Verdejo et al. in [61] for the definitive calculation. On the other hand, the transmission cost depends on the region's geographic location, which is updated in a rate study carried out every four years [62]. The distribution cost represents companies' remuneration for using medium- and low-voltage networks. This charge must be determined for the 345 regions in the country and is also updated in a study carried out every four years [35].

Figure 4 shows the algorithm scheme of the energy price stabilization mechanism for regulated clients.

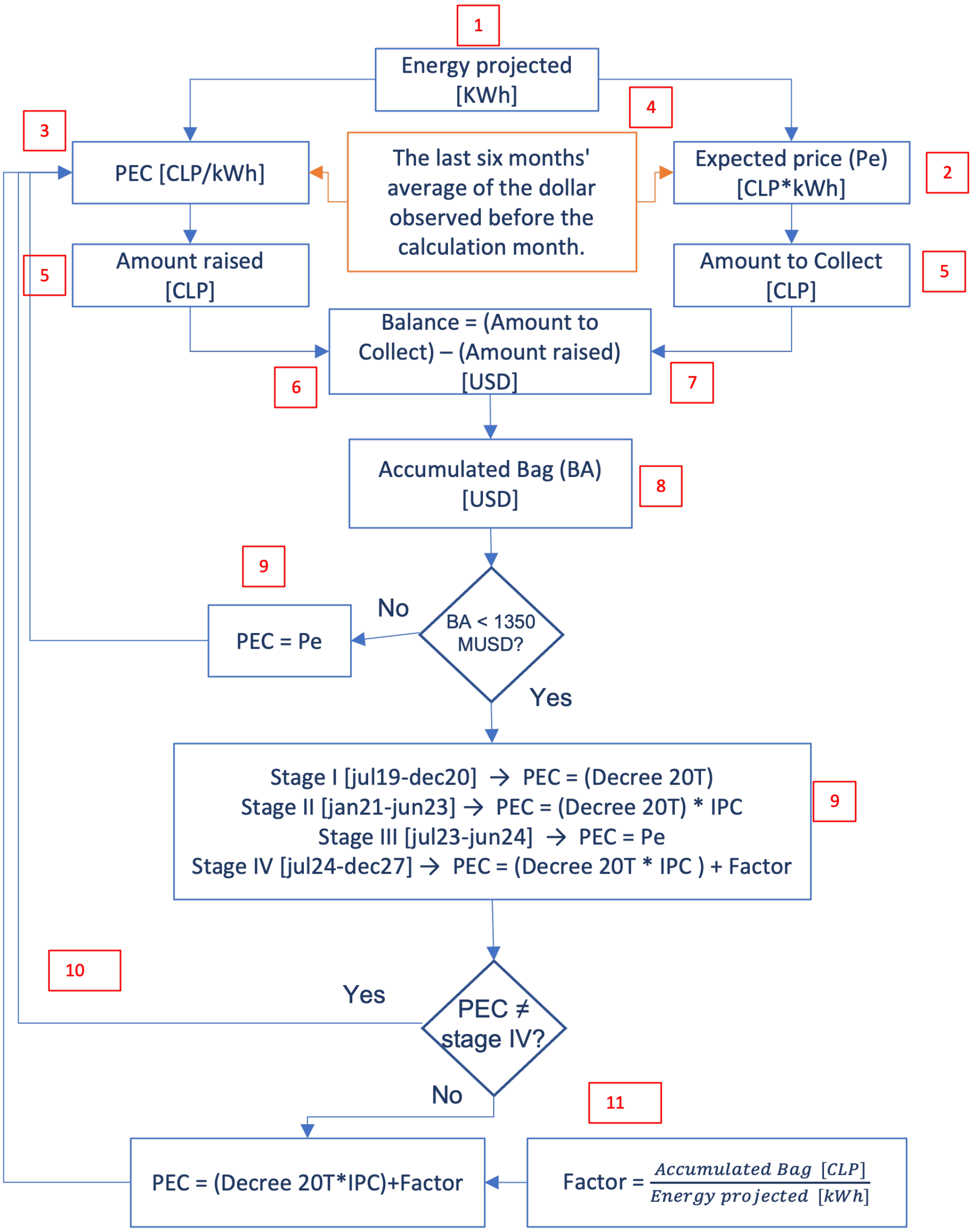


Figure 4. PEC calculation (prepared by authors).

1. Energy projected: annual energy projection provided by the national energy commission for future supply tenders in regulated customers;
2. Expected price: corresponds to the price that should be transferred to regulated customers if the stabilization mechanism had not been implemented;
3. PEC: price to be transferred to regulated customers based on the Tariff Stabilization Law;
4. Dollar: average dollar value of the last six months. The six-month methodology is established by regulation converting the price from USD/MWh to CLP/KWh;
5. Amount to collect and the amount collected: CLP monetary quantification considering the energy projected, the expected price, and the PEC;
6. Balance: difference in CLP between the amount to be collected without the PEC Law versus what was collected based on the PEC regulations;
7. Exchange rate: At this point, the regulated price is updated using the difference between the last six-month average dollar with the current month's dollar value. Therefore, the accumulated bag (BA) is updated to USD considering this difference;

8. Final accumulated bag, which could take positive or negative values;
9. PEC stage review: the PEC regulations consider that if the BA is greater or equal to 1350 MMUSD, the PEC will be equal to the expected price (Pe) in order not to continue accumulating balances. Otherwise, the price of energy to be transferred to free customers considers four stages:
   (a) The first stage is considered from June 2019 to December 2020, in which the PEC considered corresponds to Decree 20T, which sets energy and power prices for the first half of 2019.
   (b) The second stage, which runs from January 2021 to June 2023, considers that the price to be transferred to regulated clients is decree 20T, but increased by the Chilean CPI.
   (c) The third stage, which runs from July 2023 to June 2024, establishes that the price to be transferred is the Expected Price so that, in this period, it does not continue to generate BA.
   (d) Finally, the fourth stage that considers the period between July 2024 and December 2027 indicates that the price to be transferred will be Decree 20T plus IPC and a Factor that will be explained in the process.
10. After reviewing the stage that considers the PEC Law, it generates input for the prices in the new iteration;
11. Corresponds to an adjustment factor applied by the CNE to ensure the total debt payment before 2027.

Figure 5 shows the algorithm used in this article to develop the different tariff projections:

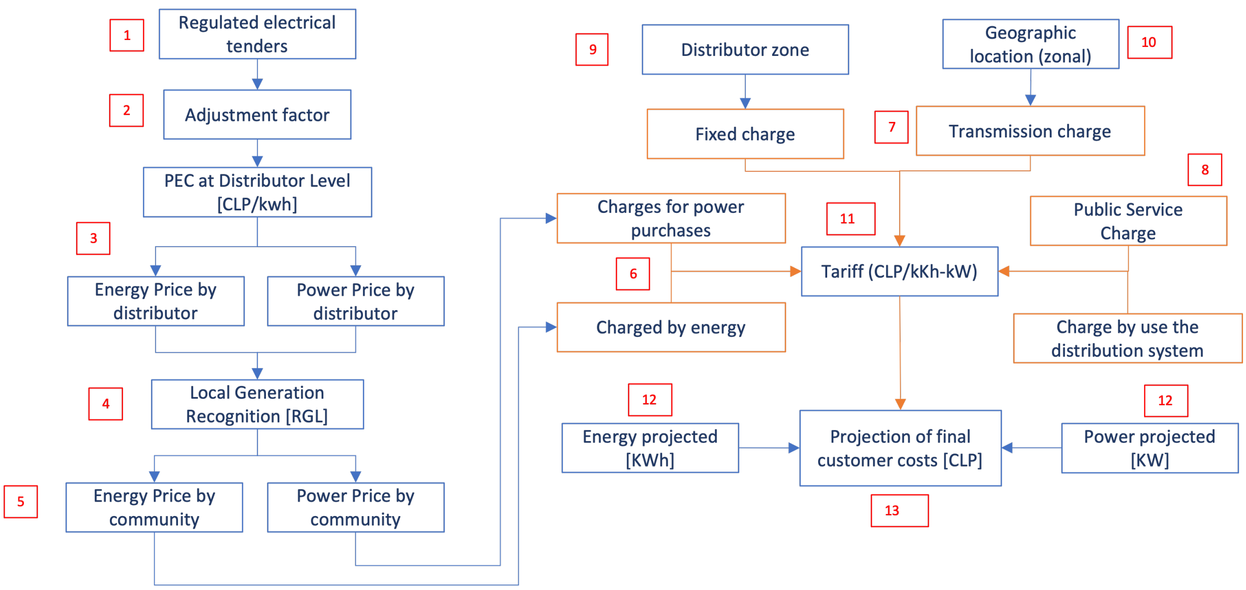


Figure 5. Electricity tariff projected methodology (prepared by authors).

1. Regulated electricity tenders: establishes the base of contracts signed to date to have the price at the distributor level to transfer to regulated customers;
2. Adjustment factor: factor to ensure that the electricity price for regulated customers is within the PEC Law ranges;
3. PEC at the distributor level: calculation of the energy and power price at distributor level considering the customers regulated prices obtained in the previous step;
4. Local generation recognition (LGR): discount applied to the zones/communities, which have local energy generation;
5. Price per commune: once the LGR per commune is obtained, these are applied to the prices of the three processes, and the energy and power prices are accepted at the communal level for the National Electric System.

6. Rate charges for power and energy: after obtaining the power and energy prices at the community level, these are used to obtain the costs associated with the final customer rate, which are used for power purchases and energy charges;
7. Charge for the distribution system uses: the distributor acts by charging the rate to regulated customers as a financial collector; therefore, this mentioned charge is the remuneration of the distributor for providing the electricity distribution service. These amounts are calculated in the four-year processes and are reflected in the calculation formula of Decree 11T;
8. Charge for public service: the charge that is transferred to the final client regarding the energy consumption of the latter and has as its objective the remuneration of the National Electrical Coordinator, the panel of experts, and the strip study. This charge is then transferred in CLP/kWh and is calculated annually by the CNE in November of each year;
9. Fixed charge: value transferred to the final customer that is not subject to minimum energy or power consumption and varies according to the specific area of the distribution company;
10. Transmission charge: the charge paid at the final customer level concerning the energy consumed is calculated by the CNE on a semi-annual basis and varies from one customer to another based on the zonal location of each of them;
11. Tariff: the grouping of each of the charges mentioned makes up the final rate paid by the regulated customer;
12. Projection: energy and power projection by segments (residential, industrial, and farming, among others) based on the obtained tariff;
13. Projection of final customer costs: finally, based on the cost of the projected rate and both projected energy and power, the projection of costs to be paid by final customers is obtained.

5. Results

According to the accumulated balance to date and the forecasting for 2021 based on the energy demanded by regulated customers, the dollar price, and the current update in the active contract prices, the PEC mechanism will complete the maximum debit balance by the end of 2021, almost two years before what was initially established in Law 21.185. Therefore, since 2022, the regulated tariff would not accumulate more debt, disabling the PEC mechanism and transferring the real electricity price to the customer, producing a significant price increase.

Figure 6 presents the situation described above. The green line reflects the expected value for customers, considering the PEC mechanism ending at the beginning of 2022 and not at the end of 2023, as established in Law 21.185 initially. On the other hand, the blue line shows the PNP forecasting, considering the existing contracts. In addition, it has been included in the grey bars the balance projections to be returned by final consumers produced by the accumulated difference between 2019 and 2021 by the PEC mechanism and the real price. Thus, Figure 6 allows inferring some findings:

- Due to the debt stock saturation, a significant increase in the price perceived by the customers is expected for 2022.
- At the end of 2027, the expected electricity price and the PEC are equal, such as established Law 21.185. However, due to the final price distortion produced by the PEC mechanism implementation, the price until 2028 will be higher than the real price presented in 2019, also affecting the price reduction by the generation tenders based on renewable resources.
- The real electricity price will not drop significantly until 2032 because, in that year, the contracts awarded with high prices will be finished, specifically the 2013-03/2 tender.
- The PEC price for the first semester should be equal to the PNP; however, the dollar used to set the PEC price was significantly lower (USD 640.82) than the real dollar projections. Thus, the transfers rate to regulated customers considers a low exchange

rate compared to the real exchange rate, one of the main reasons for the rapid balance increase of USD 1350 MM.

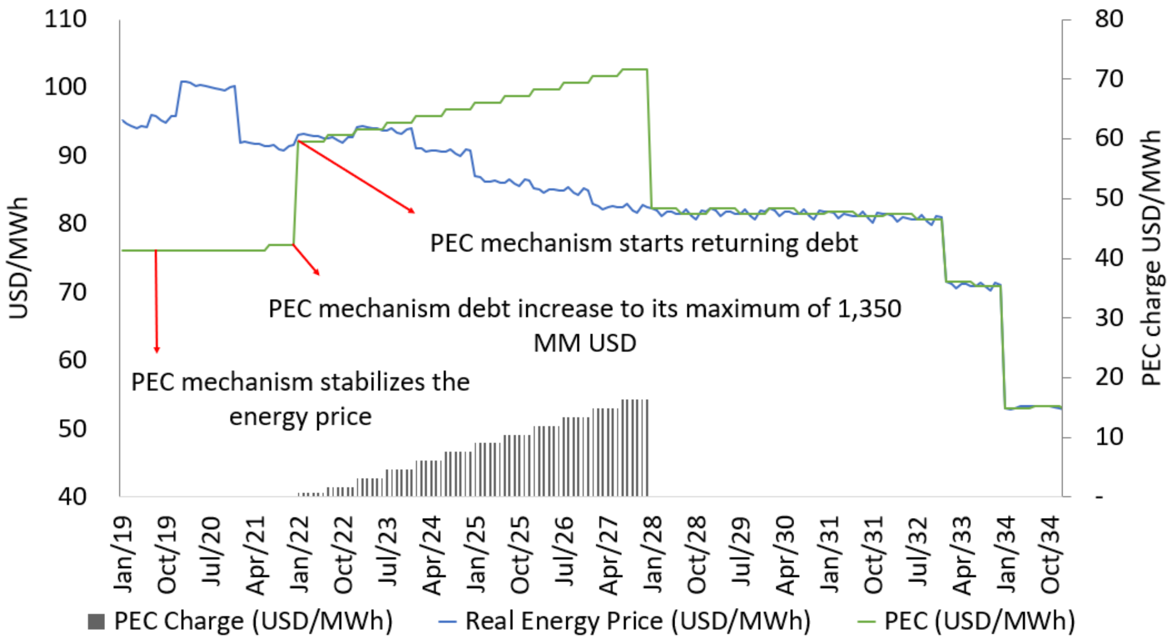


Figure 6. Real energy price (PNLP) versus Law 21.185 (PEC). Based on the data in [60].

The grey bars have been estimated using the regulated electricity price forecasting, the period to return the debt aggregated (2027), and the balance and exchange rate projection. Thus, at the end of 2027, the customers must pay the total aggregate debt independently if the customer changes to a free tariff during this transition period.

Short-Term Proposal to Face the Regulated Tariff

The previous section shows that the regulated tariff will not decrease until 2032; rather, it will increase significantly from 2022. A short-term proposal to face a future higher tariff is to migrate the regulated customer to a free tariff scheme since this scheme is available for customers with a power consumption of over 500 kW, showing significant savings with an energy price of around 50 USD/MWh in contrast with the regulated scheme.

Figure 7 shows the hypothetical case of customers moving to the free tariff through (i) a green line, which corresponds to the expected PEC value; (ii) a blue line, representing the free tariff; and (iii) a gray line, which forecasts the payment of the outstanding balance that the customer must return to the generation companies. In this regard, in Figure 3, the free tariff, including the outstanding payment (gray line), is always below the regulated tariff (green line), allowing the customers to save almost 44% on their electricity bill in 2022 and close to 38% in total.

For a significant migration of regulated customers, the Free Competition Court by means of the Energy Minister must reduce the current contracted power limit (500 KW) to 100 kW and include it in Article 147 of the General Law of Electric Services. Nevertheless, one of the controversial points in reducing the limit of power is the energy contracted by tendering. Figure 8 presents the current tenders and the electricity demand related to the regulated customers. Thus, the over contracting of energy until 2025 is clear, as the CNE has reported in the annual energy projection. Nevertheless, under the context of over-contracted energy, it is feasible to reduce the limit power to opt for a free tariff in the short term, providing significant savings to the customers and SMEs.

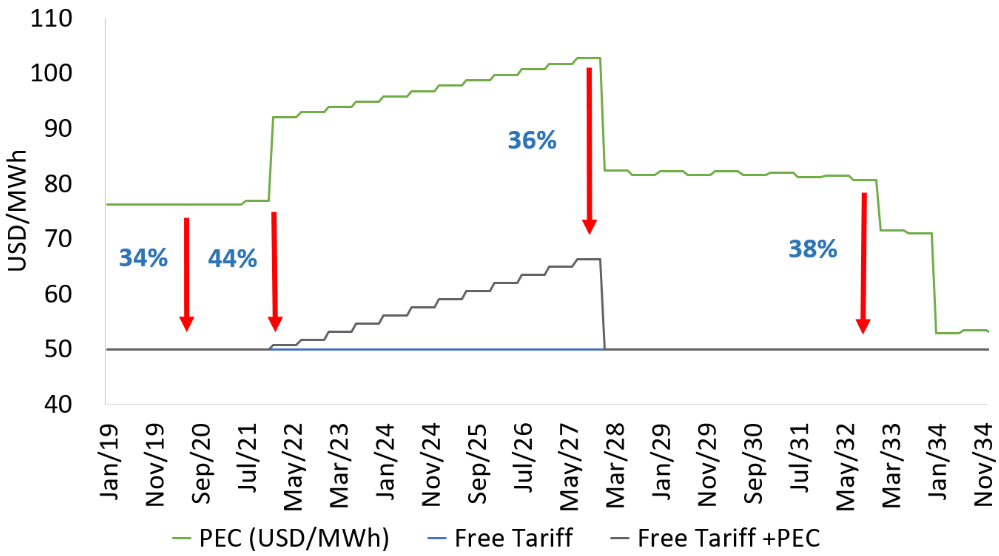


Figure 7. Savings for customers who move from a regulated scheme to a free scheme. Based on the data in [60].

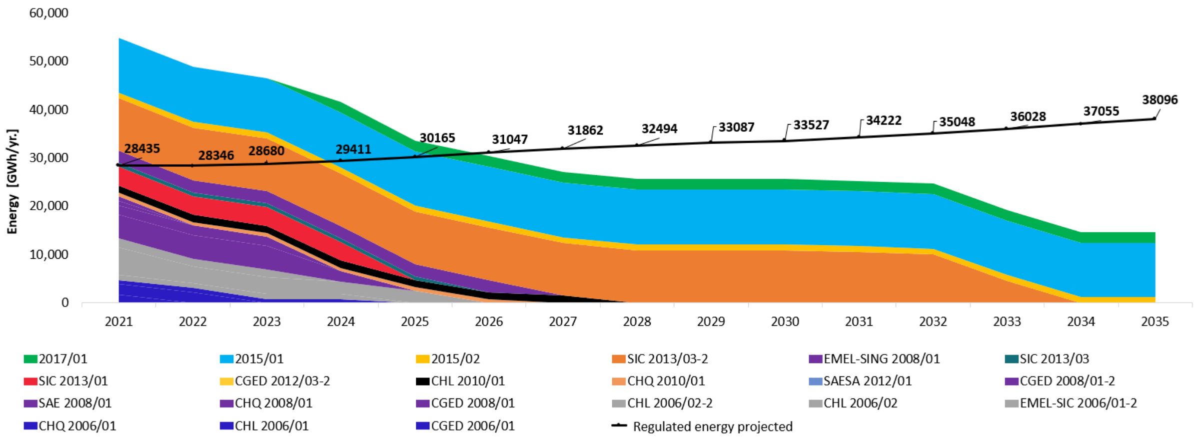


Figure 8. Energycontracted and projected. Based on the data in [60].

6. Discussion

The savings estimated in this article for customers under a regulated tariff that migrate to a free tariff are shown in the following figures, considering that customers can freely choose to move to a free scheme (with 100 kW as a limit) and select their electricity provider under a liberalized retail electricity market.

The simulations are developed for the years 2024, 2027, and 2030 considering customers belonging to the cities from the north to south of Chile, Antofagasta (Figure 9), Santiago (Figure 10), and Puerto Montt (Figure 11), under the four usual regulated tariffs, which are BT1, BT2, BT3, and BT43. The residential households are allocated in the BT1 tariff, while the SMEs follow the remaining tariffs, depending on their power consumption. Thus, the SMEs would see a reduction in their electricity bill by over 22% in the short term, which would imply a high impact on the economy due to the SME segment representing 80% of the country's employment. In addition, the residential households would reduce electricity costs by around 14%, equivalent to the drinking water bill (USD 8) for the most vulnerable sector.

In addition, Figures 9–11 show the results of using the algorithms explained in Section 4 to observe the reduction tariff effect for three representative regional capitals of Chile under a free market scheme. Thus, the residential tariffs may decrease by 20%, 18%, and 16% for users in the north, center, and south, respectively, the northern customers being the ones with the greatest savings potential under a free tariff. On the other hand, for commercial and industrial customers, the simulation indicates an expected savings of around 27%, 24%, and 25% (similar for SMEs under BT2 and BT3 tariffs), respectively, which means a significant savings margin that could be used as public politic to promote economic reactivation after the pandemic.

The above difference between the north and center–south zones is explained because the electric power generation in the Chilean north is based on thermal energy, and the other zones are based mainly on hydraulic systems (at least until 2012). This power generation contrast has implied expensive tenders for northern customers since 2008 and, hence, higher regulated tariffs than the central–southern customers. Therefore, users with the current expensive regulated tariff are the ones that would have the most significant saving capacity if they move to a free rate system.

Under a health emergency context, the above saving means a significant help to the country's economy, including the most vulnerable homes and the primary production sector. However, to advance in this sense, it is imperative to liberalize the Chilean retail electricity market and reduce the power limit to move from a regulated to a free tariff. Likewise, under a free competition retail market, SMEs could choose a provider who bases its generation on renewable resources, which could impact the services and products provided by the SMEs.

The liberalization of the retail electricity market is a change that will generate savings for users and change the way customers relate to the electricity matrix, thus establishing fundamental guidelines on how energy is produced in the country. Thus, a gradual liberalization focused on SMEs could ideally be considered a helpful mechanism for small companies, which does not require additional funds from the state, but only a decree from the Ministry of Energy.

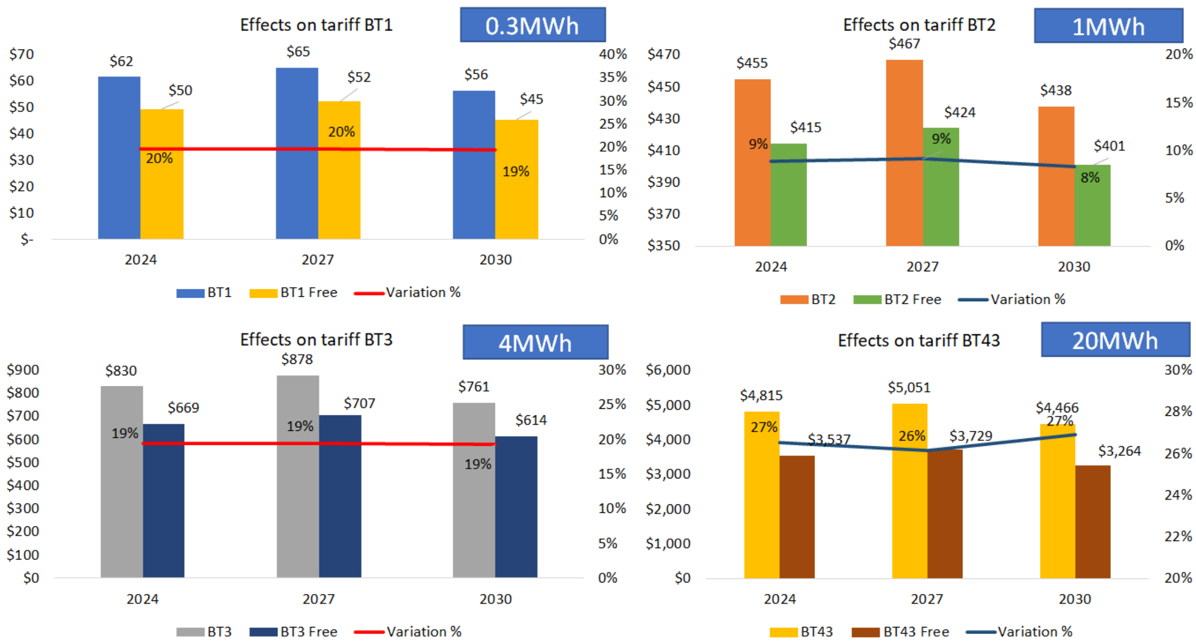


Figure 9. Antofagasta : savings considering regulated tariff vs. free tariff.

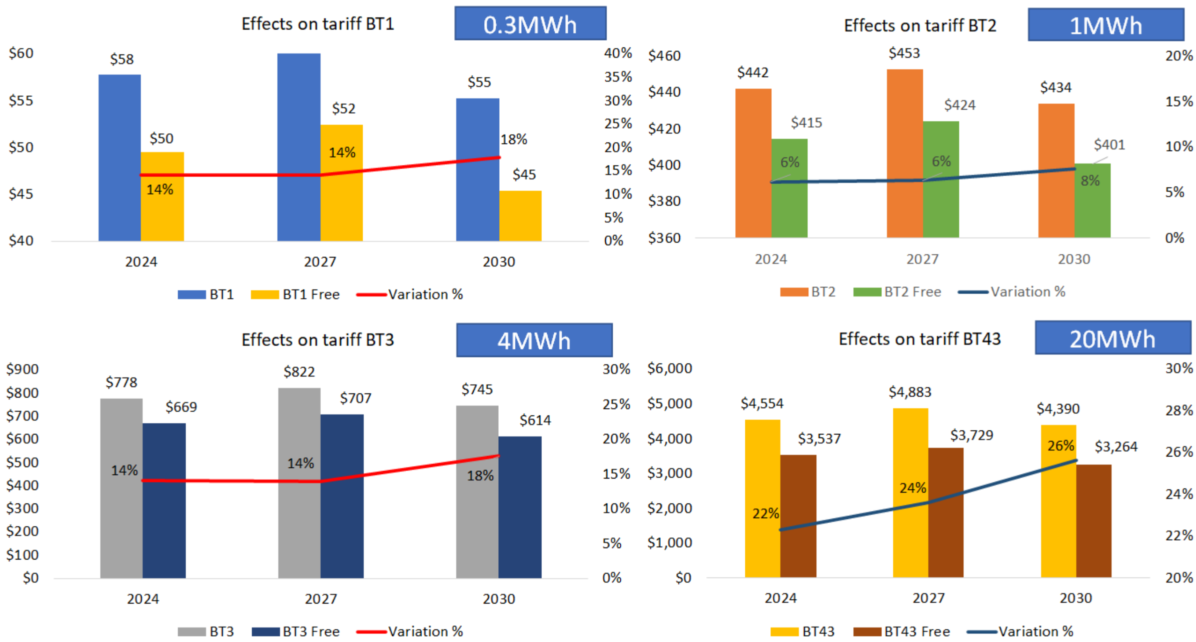


Figure 10. Santiago: savings considering regulated tariff vs. free tariff.

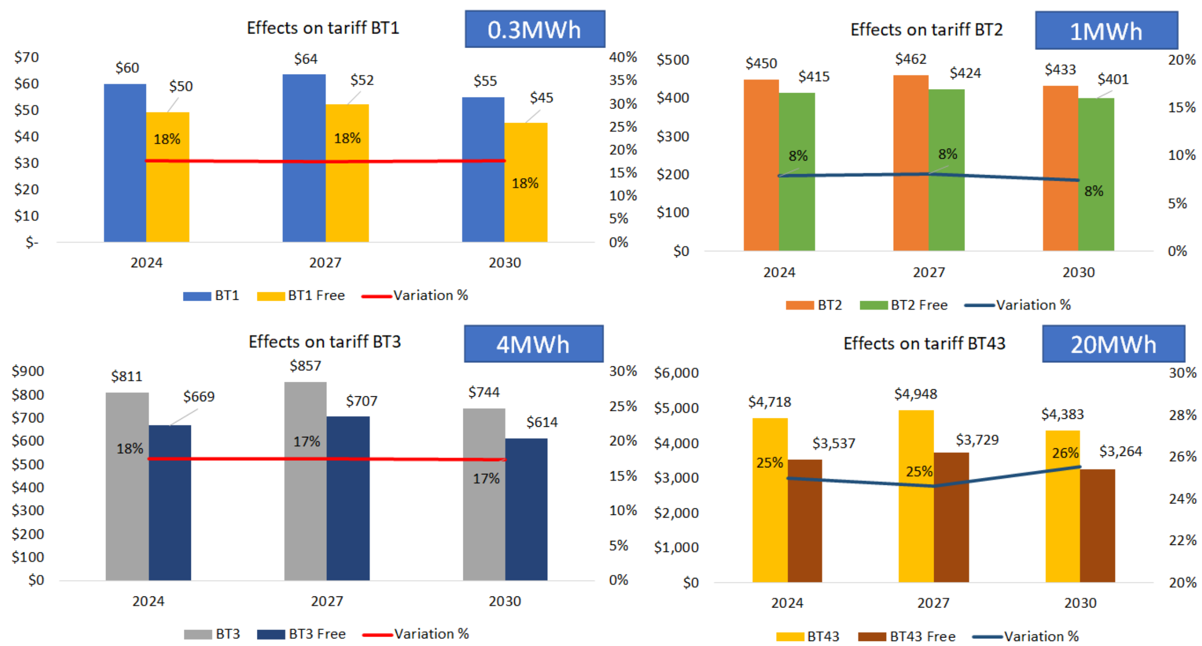


Figure 11. Puerto Montt: savings considering regulated tariff vs. free tariff.

7. Conclusions

The effects of pricing on Chilean residential and commercial customers under a regulated scheme have been addressed under an the framework of an eventual retail electricity market liberalization based on international experiences, current Chilean tenders, and political measures. In this regard, the competitiveness and pricing report generated by the European Commission for countries under a fully liberalized scheme have been used to support the pricing effect on the Chilean market. Thus, regulated tariff forecasting to 2034 has been presented to study the long-term effect of the current mechanisms to control high electricity prices, and multiple simulations have been developed to measure the potential impact of liberalizing the retail electricity market on customers under regulated tariffs.

The results have shown that the price reduction in the last tenders, promoted by a high RES penetration, on the wholesale market in Chile does not transfer to the customer under a regulated tariff due to (i) the current mechanism in place to fix the price, based on weighted averages for tenders, increasing the final price; (ii) there is not a retail market for regulated customers; and (iii) the current mechanism to stabilize the energy price creates distortions in the middle-term, increasing the price in the following years. On the other hand, the simulations have shown that commercial and residential customers could face increased regulated tariff price savings of around 15–20% if the retail electricity market is liberalized.

Therefore, the results suggest that to increase the retail electricity market's competitiveness and reduce the costs for residential and small commercial customers, the current Chilean government must proceed in liberalizing the retail market and reducing the power limit to opt for a free tariff. Thus, new competitors could decentralize the market power concentrated in the most prominent supplier company and offer competitive prices to the customers. In this sense, future research could study hourly tariff implementation for commercial and residential customers depending on the smart meter rollout.

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Nomenclature

EU	European Union
EC	European Commission
DSO	Distribution system operator
TSO	Transmission system operator
SM	Smart meters
RES	Renewable energy sources
FIT	Feed-in tariff
FIP	Feed-in premiums
GC	Green certificates
NEM	Net-metering
RPS	Renewable portfolio standard
RD	Royal decree
DL	Decree law
SME	Small- and medium-sized enterprises
CEER	Council of European Energy Regulators
CNE	Energy national commission
PNP	Average knot price
PEC	Price for regulated costumers

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