FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

Analysis of the Auction and Continuous Intraday Electricity Markets of the MIBEL

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June 28, 2021

Abstract

In 2007 the Iberian Electricity Market, MIBEL, was born as a result of the cooperation between Portugal and Spain aiming at the integration of the power systems of both countries. This not only meant the establishment of an electricity market at the Iberian level but also corresponded to a big step towards the creation of an Internal Energy Market all around Europe.

MIBEL is organised in three different markets: Day-Ahead Market, Intraday Auctions Market and Continuous Intraday Market. The Day-Ahead Market is responsible for the large majority of the electricity transactions, while both of the intraday markets allow the agents to adjust their programs that resulted from the day-ahead market according to their closer to real time necessities.

Since its creation, MIBEL has suffered some changes due to the increase in production coming from renewable resources, the increase in the interconnection capacities and the adjustments of demand patterns in both countries. The improvement of the Intraday Markets has allowed a better optimization of the use of electricity generation assets, especially coming from renewable sources, and also enabled the development of the participation of the demand in the market.

The objective of this work is to analyse both the Intraday Auctions Market and the Continuous Intraday Market in the Iberian Electricity Market, from 2018 until 2020, covering energy prices, volume of energy traded, clearing agents and the influence of the different generation technologies for energy production. The results of this analysis are then compared with the results of the Day-Ahead Market.

The Intraday Auctions Market average price in 2018 was 64,31 €/MWh with 37357 GWh of traded energy. In 2019 there was a decrease in both traded energy and average price values to 48,05€/MWh and 34088 GWh. For 2020 the average yearly price was 34,47 €/MWh at a volume of 31081 GWh of traded energy. The agent, owner of generation bid units, with the biggest share of the Intraday Auctions Market over all three years was Gas Natural Comercializadora, and for the owner of purchase bid units was EDP-Energias de Portugal. Over the years in study the Intraday Auctions Market recorded an increase in the share of energy produced by more greener technologies, such as wind and solar.

As for the Continuous Intraday Market, the average price in 2018 was established at 63,22 €/MWh with 1030 GWh of traded energy. In 2019 the average yearly price was 47,24 €/MWh at 2179 GWh of traded energy, and the average yearly price and total volume of traded energy in 2020 were 33,68 €/MWh and 3534 GWh. The agent with the largest shares of the Continuous Intraday Market for both generation and purchase bid units was EDP-Energias de Portugal. Similar to the Intraday Auctions Market, the Continuous Intraday Market had an increase in the share of wind and solar energy generation throughout the three analysed years.

Resumo

Em 2007 nasceu o Mercado Ibérico de Electricidade, MIBEL, como resultado da cooperação entre Portugal e Espanha com vista à integração dos sistemas de energia de ambos os países. Isto não só significou o estabelecimento de um mercado de electricidade a nível ibérico, mas também correspondeu a um grande passo para a criação de um Mercado Interno de Energia em toda a Europa.

O MIBEL está organizado em três mercados diferentes: Mercado Diário, Mercado Intradiário de Leilões e Mercado Intradiário Contínuo. O Mercado Diário é responsável pela grande maioria das transacções de electricidade, enquanto que ambos os mercados intradiários permitem aos agentes ajustar os seus programas resultantes do Mercado Diário de acordo com as suas necessidades mais próximas das necessidades em tempo real.

Desde a sua criação, o MIBEL sofreu algumas alterações devido ao aumento da produção proveniente de recursos renováveis, ao aumento das capacidades de interligação e aos ajustes dos padrões de procura em ambos os países. A melhoria dos Mercados Intradiários permitiu uma melhor optimização da utilização dos activos de produção de electricidade, especialmente provenientes de fontes renováveis, e também possibilitou o desenvolvimento da participação da procura no mercado.

O objectivo deste trabalho é analisar tanto o Mercado Intradiário de Leilões como o Mercado Intradiário Contínuo no Mercado Ibérico de Electricidade, desde 2018 até 2020, abrangendo os preços de energia, o volume de energia comercializada, os agentes de compensação e a influência das diferentes tecnologias de geração para a produção de energia. Os resultados desta análise são então comparados com os resultados do Mercado Diário.

O preço médio do Mercado Intradiário de Leilões em 2018 foi de 64,31 €/MWh com 37357 GWh de energia comercializada. Em 2019 houve uma diminuição tanto no valor da energia transacionada como no preço médio para 48,05 €/MWh e 34088 GWh. Para 2020 o preço médio anual foi 34,47 €/MWh para um volume de 31081 GWh de energia comercializada. O agente, proprietário de unidades de produção de energia, com a maior quota do Mercado Intradiário de Leilões ao longo dos três anos foi a Gas Natural Comercializadora, e para o proprietário de unidades de compra de energia foi a EDP-Energias de Portugal. Ao longo dos anos em estudo, o Mercado Intradiário de Leilões registou um aumento na quota de energia produzida por tecnologias mais ecológicas, tais como a eólica e a solar.

Quanto ao Mercado Intradiário Contínuo, o preço médio em 2018 foi estabelecido em 63,22 €/MWh com 1030 GWh de energia comercializada. 2019 apresentou um preço médio anual de 47,24 €/MWh a 2179 GWh de energia comercializada, e o preço médio anual e o volume total de energia comercializada em 2020 foram 33,68 €/MWh e 3534 GWh. O agente com as maiores quotas do Mercado Intradiário Contínuo, tanto para unidades de produção como para unidades de compra, foi a EDP-Energias de Portugal. Semelhante ao Mercado Intradiário de Leilões , o Mercado Intradiário Contínuo teve um aumento na quota de produção de energia eólica e solar ao longo dos anos.

Acknowledgements

To my supervisors, Professor João Tomé Saraiva from FEUP and Professor José Villar Collado from INESC TEC, for their time, patience, constructive feedback and excellent guidance throughout this dissertation process.

To BEST Porto for the second home that they gave me, pushing me to improve and challenge myself, allowing me to create new friendships and to work with different types of people. Providing me with memorable experiences far exceeding my expectations for my university years.

To André and Neiva for their support, friendship, words of motivation and company.

To my family, specially my parents for their unconditional support and patience, providing me with a good environment to grow with everything needed to succeed. And my siblings for their constant support and for being the best role models pushing me to follow my dreams.

Luis Ferreira Monteiro

"Time you enjoy wasting is not wasted time."

Bertrand Russell

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Abbreviations and Symbols

CET	Central European Time
CIM	Continuous Intraday Market
CMM	Capacity Management Module
CMVM	Comissão do Mercado de Valores Mobiliários
DAM	Day-Ahead Market
ES	Spain
EU	European Union
IAM	Intraday Auctions Market
LTS	Local Trading Solution
MIBEL	Iberian Electricity Market
NEMO	Nominated Electricity Market Operator
OMI	Iberian Market Operator Group
OMIE	Iberian Electricity Market Operator - Spanish Hub
OMIP	Iberian Market Operator - Portugueses Hub
PHFC	Plano Horário Final Contínuo
PT	Portugal
SIDC	Single Intraday Coupling
SM	Shipping Module
SOB	Shared Order Book
XBID	Cross-Border Intraday

Chapter 1

Introduction

1.1 Framework and objectives

In 2007 the Iberian Electricity Market, MIBEL, was born as a result of the cooperation between Portugal and Spain aiming at the integration of the power systems of both countries. This not only meant the establishment of an electricity market at the Iberian level but also corresponded to a big step towards the creation of an Internal Energy Market all around Europe.

While the day-ahead market is responsible for the large majority of the electricity transaction, both the intraday auctions market and the continuous intraday market allow agents to adjust their programs that resulted from the day-ahead market according to their closer to real time necessities, being the biggest change to MIBEL's structure the addition of the continuous intraday market in 2018.

The main scope of this work is to analyse the impact of the intraday markets in the Iberian Electricity Market, from the beginning of the continuous intraday market in June 2018 until the end of 2020. This analysis covers the energy prices, traded energy volume, the clearing agents and the influence of the different generation technologies for energy production. The results of this analysis are then compared with the results of the day-ahead market.

This work was performed in a partnership between the Faculdade de Engenharia da Universidade do Porto and INESC-TEC with the intention of expanding the knowledge about the Continuous Intraday Market.

1.2 Document Structure

The present document is organised in 6 chapters. This first chapter is structured in two parts, the first one being about the framework and the objectives of this thesis while the second one presents the document structure.

Chapter 2, Iberian Electricity Market, includes the most important information about the power systems of Portugal and Spain and its structure, going into further detail on the operation and historical background of both intraday markets.

Chapter 3 analysis the energy prices, and describes the results for 2018, 2019 and 2020, regarding average prices per year, month, day, hour and session or round for the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market.

In a similar way, Chapter 4, Analysis of the traded energy, presents the results for the total volume of traded energy per year and month, and for the average amount of traded energy per day, hour and session or round in both Intraday Markets, comparing them with the Day-Ahead Market to assert their relation with each other.

Chapter 5, describes the top clearing agents for each market in the last three years and analysis de evolution of the production of energy by technology throughout the years for each market.

Finally, Chapter 6 presents the main conclusions regarding the analysis of the results obtained in Chapters 3, 4 and 5 and enumerates some suggestions of possible future work.

Chapter 2

Iberian Electricity Market

2.1 Historical Background

The Iberian Electricity Market, MIBEL, was born as a result of the cooperation between Portugal and Spain aiming at the integration of the power systems of both countries with the principles of transparency, free competition, objectivity, liquidity, self-financing and self-organisation of markets. This not only meant the establishment of an electricity market at the Iberian level but also corresponded to a big step towards the creation of an Internal Energy Market all around Europe [7].

Regarding the implementation of the Internal Energy Market, in December 1996, the European Directive 96/92/CE was published with the objective of developing the regional electricity markets aiming at the creation of an European electricity market. In this on-going development, in 1998, both the Portuguese and Spanish governments began conversations about the establishment of MIBEL which was marked by the events listed in Table 2.1.

Table 2.1: Roadmap of the most important events for the creation of MIBEL [7]

Date	Event
November 2001	Signing of the Protocol for the Cooperation between Portugal and Spain for the establishment of the Iberian Electricity Market.
October 2004	Signing of the Agreement in Santiago de Compostela between the Portuguese Republic and the Kingdom of Spain.
November 2006	22nd Luso-Spanish Summit of Badajoz took place.
July 2007	MIBEL was fully launched and brought to a successful conclusion the harmonisation of requirements between the two power systems.
January 2008	Signing of the Agreement in Braga which revises the Santiago Agreement.

According to OMIP, MIBEL was launched with the following objectives:

- **T**o benefit both countries' electricity consumers through the integration of their power systems;
- **T**o organize the market's operation around the concepts of transparency, open competition, objectivity, liquidity, self-financing, and self-organization;
- **T**o promote the growth of both countries' electrical markets using a single, integrated system for determining reference prices across the Iberian Peninsula;
- **T**o provide free market access to all participants, with equal rights, obligations, transparency and objectivity;
- **T**o encourage open competition amongst companies in the electrical sector in order to improve their economic efficiency. [9]

2.2 Structure and Operation

The Iberian Electricity Market was established based on a mixed model, including a symmetric pool in which there are the day-ahead, the auction intraday and the continuous intraday markets, and the physical and financial bilateral contracts.

On the 20th Luso-Spanish Summit in Santiago de Compostela, in October 2004, a new operating structure was approved in which the Iberian Market Operator, OMI, was converted in a bipolar entity that integrates two societies: the OMIP, Operador do Mercado Ibérico (Portugal), SGPS, S.S (OMIP SGPS) and the OMEL, Operador del Mercado Ibérico de Energía - Polo Español, S.A, in Madrid. Each of the managing firms has a fifty percent stake of OMIClear- Sociedade de Compensação de Mercados de Energía, SA. This structure is illustrated in Figure 2.1 [10].

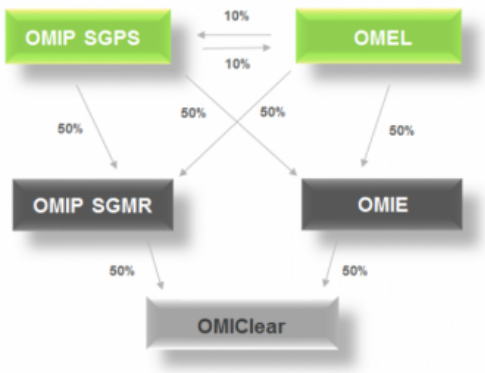

Figure 2.1: Iberian Market Operator's share of each society [1]

Figure 2.2 presents the organisational model of OMI.

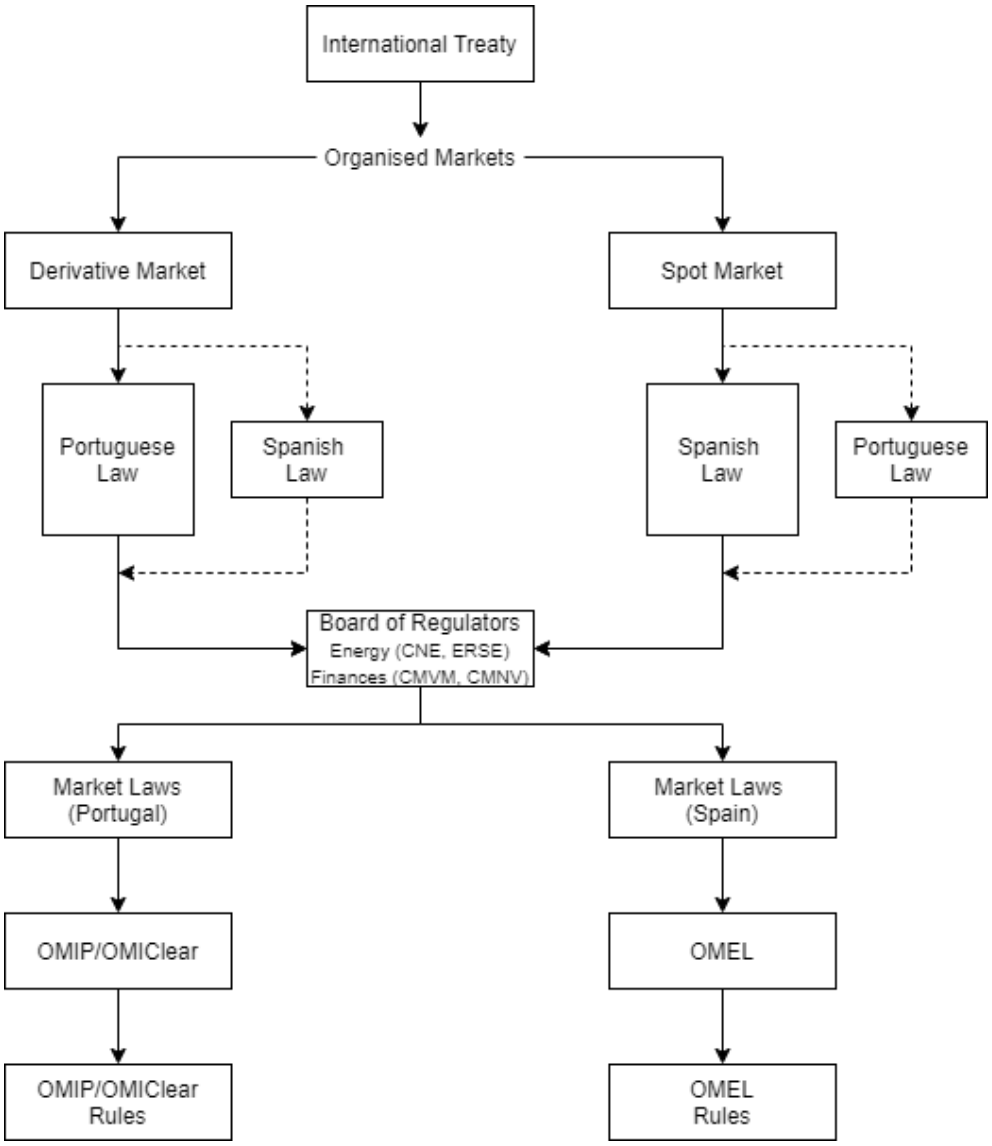

Figure 2.2: Organisational model of OMI [2]

2.3 OMIP - Operador do Mercado Ibérico (Polo Português)

According to the International Agreement between Portugal and Spain, the Portuguese Hub, OMIP, is a Regulated Market Operator that provides a trading platform for energy products. CMVM (the Portuguese Securities Market Commission) is in charge of both OMIP and its activities, in accordance with the applicable National and European laws and regulations of the financial sector [1].

The Derivatives Market is open to trade products with electricity and natural gas as underlying assets that are exchanged daily by agents in Portugal, Spain and other countries. OMIP also provides other services, such as market solution development, implementation, management, and operation in a variety of fields, but mainly in energy and telecommunications. OMIP is focused

on auctions for electricity, natural gas, wind energy production licenses, Portugal-Spain interconnection, capacities, special regime generation, etc [1].

OMIP is responsible for the negotiations while OMIClear is in charge of their registry and agents risk management, as it is shown in Figure 2.3. All negotiations made through OMIP are anonymous which means that the market participants do not have access to information about the identity of buying or selling agents. All the market offers are public to its participants, consequently, they can exploit eventual imbalances that might result from the gaps between supply and demand of each product [3].

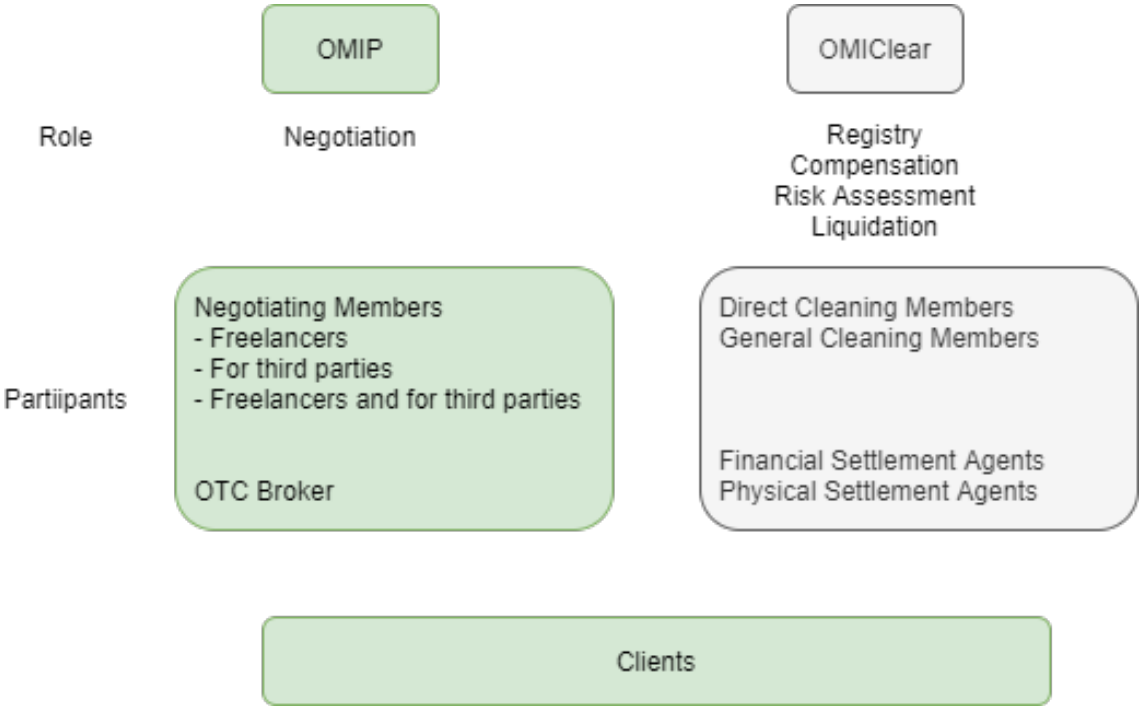

Figure 2.3: Organisation of the market: OMIP and OMIClear [3]

2.4 OMIE - Operador del Mercado Ibérico de Energía (Polo Español)

OMIE is the Spanish Hub for the Iberian Market Operator and also the Nominated Electricity Market Operator (NEMO) for managing MIBEL's day-ahead and intraday markets. OMIE is actively participating in connecting European electricity markets, along with all the NEMO's of each EU member state [11].

2.4.1 Day-Ahead Market

The MIBEL Day-Ahead Market's main objective is to handle electricity transactions for the following day through the submission of electricity sale and purchase bids by market participants. It

is the main market for electricity transactions in the Iberian Peninsula and it operates all year long [8, 12].

Every day at 12 CET, there is a session of the day-ahead market in which the prices and volumes of electricity to be generated and consumed are determined for the next 24 hours. The price and volume of energy in one specific hour are determined by the balance between the supply and demand following the model agreed upon by all European markets [8, 12].

Buying and selling agents in Portugal or Spain present their bids to the day-ahead market through OMIE. Their bids are accepted based on their economic value and the availability of interconnection capacity between the two price zones. If the interconnection capacity between the two zones is sufficient to allow the electricity flow that came from the negotiation at a specific time of day, the pricing in both zones will be the same. Otherwise, if in that hour the interconnection is maxed out, the algorithm will determine a different price for each zone, this is called market splitting [8, 12].

The day-ahead market follows a marginal based model, both supply and demand bidding curves are crossed for each hour of the following day. This way, demand bids are sorted in descending order and supply bids in ascending order, according to their prices, establishing the meeting price of the market and the respective energy volume corresponding to each time period of the following day. The same process can be visualized in Figure 2.4.

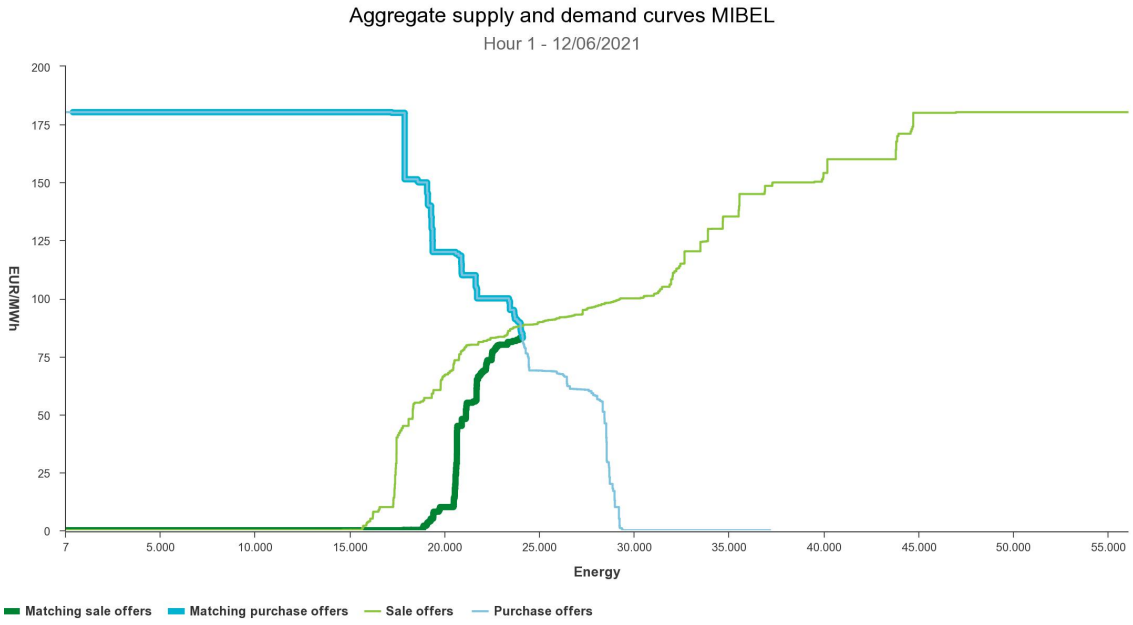

Figure 2.4: Aggregate supply and demand curves of MIBEL for the first hour of 12-06-2021 [4]

Selling bids presented to the Market Operator can be simple or complex depending on their content. Simple bids are selling offers that are presented for each time period and production unit with set prices and quantity values. Complex bids are those that even complying with the simple bid requirements also have some extra technical or economic conditions: [8]

- **Indivisibility:** — allows for a minimum operating value to be set in the first block of each hour. This value may only be divided by applying distribution rules if the price is different from zero.
- **Load gradients:** — enables the maximum difference value between the energy produced in an unit in two consecutive hours to be established, limiting matchable energy in those hours in order to avoid sudden changes in production.
- **Minimum income:** — enables bids to be submitted at any time, provided that a production unit does not participate in the day's matching results if its income level does not surpass a particular amount, set in euros, plus a variable payment set in euros for each matched MWh.
- **Scheduled stop:** — enables production units that have been removed from the matching process due to failure to meet the stipulated minimum income condition to perform a scheduled stop for a maximum of three hours, avoiding schedule disruptions by accepting the first slot of the first three hours of their bids as simple bids, with the only condition being that energy offered in bids must drop hourly.

In accordance with Article 10 of Regulation (EU) 2019/943 of June 5, 2019 the maximum and minimum price limits for the daily market in the zone MIBEL (Spain and Portugal), were changed as to not unnecessarily restrict trade. However, post analysis of the MIBEL price records, there were no prices above or bellow the previous price limits of 180,3 €/MWh and 0€/MWh in this market [13].

The results obtained from the matching process are then sent to the System Operators of both countries for validation from the point of view of technical feasibility. Which means that the results may suffer slight changes as a consequence of the restriction analysis, resulting in a much more viable daily program [8, 12].

2.4.2 Intraday markets

The intraday markets are important tools that allow the market agents to adjust their program that resulted from the day-ahead market in accordance with their real time-needs, by submitting new energy bids.

The intraday markets are structured in six auction sessions on the Iberian level and in an European cross border continuous market, and are carried out after the System Operator has made the necessary adjustments after the day-ahead market so that the resulting schedule is already viable according to grid constraints.

Just like the day-ahead market, after these markets take effect, the results are sent to the System Operators so that they can schedule the balancing processes [8].

2.4.3 Intraday Auctions Market

The intraday auction market consists of six sessions with different programmed horizons and manages the zonal prices of Portugal and Spain, and the interconnection capacities of: Spain-Portugal, Spain-Morocco and Spain-Andorra where the energy volume and price of each hour is determined by the intersection between supply and demand [8].

Just like the day-ahead market, the intraday auction market follows the marginal based model and the coupling model for the borders of Portugal and Spain.

Nowadays, the six mentioned sessions have the hourly distribution indicated in Table 2.2 but before the 12th November of 2019, the hourly distribution was as presented in Table A.1 of Appendix A [6, 14].

Table 2.2: Hourly distribution per session [8]

	SESSION 1ª	SESSION 2ª	SESSION 3ª	SESSION 4ª	SESSION 5ª	SESSION 6ª
Auction Opening time	14:00	17:00	21:00	1:00	4:00	9:00
Auction Closing time	15:00	17:50	21:50	1:50	4:50	9:50
Matching Process	15:00	17:50	21:50	1:50	4:50	9:50
Results publication (PIBCA)	15:07	17:57	21:57	1:57	4:57	9:57
TSOs Publication (PHF)	16:20	18:20	22:20	2:20	5:20	10:20
Schedule Horizon (Timing periods included in the horizon)	24 hours (1-24 D+1)	28 hours (21-24 y 1-24 D+1)	24 hours (1-24 D+1)	20 hours (5-24)	17 hours (8-24)	12 hours (13-24)

2.4.3.1 Bidding in the Intraday Auctions Market

All market agents are able to present their bids, simple or with complex conditions, at the intraday auctions. Simple bids are economic offers of energy supply or demand, of 1 to 5 stretches, that suppliers present to each time period and unit that they own. These bids contain a price and a volume of energy, being the price increased at each stretch. Bids that include complex conditions are those that after following the requirements of a simple bid incorporate all or some of the conditions below:

- **Load gradient and minimum income, maximum payments:** — similarly to the day-ahead market. The maximum payment condition is equivalent to the minimum income applied to energy purchases, that will not be matched in case of the cost being superior to a fixed value plus one variable per matched kWh;
- **Full acceptance in the matching of the first stretch of the selling bid:** — allows the supplying offers to fix a profile for all the hours in the intraday market, that can only result as matched if it is in the first stretch of every hour. This allows the adjustment of unit programs to a new profile, or in case it is not fully possible, to leave a previous program without any modification of each hour individually;

- **Full acceptance in each hour in the matching of the first stretch of the selling bid:** — implies that the first stretch will only be programmed if it is matched in its entirety;
- **Condition of minimum number of consecutive hours of full acceptance of the first stretch of the sale bid:** — it could be applied when a unit stops producing/consuming consecutively at least a number of hours;
- **Maximum energy:** — it allows units to have a limitation on the availability of energy, but limiting the matched value to a global max of energy [8].

Similarly to the Day-Ahead Market, the maximum and minimum price limits for the Intraday Auctions Market were changed. There were also no prices found in chapter three that surpassed any of the previous limits [13].

2.4.3.2 Matching Process and results in the Intraday Auctions Market

The Market Operator will match supply and demand bids through a simple or complex matching method according to what type of bid it is. The simple matching approach is the one that independently obtains the marginal price, just like the energy volume that is accepted for each offer in each programmed time period [15].

The complex matching method starts by obtaining the result of the simple matching process and then it adds the condition of the load gradient. Then it uses an iterative process that is executed multiple times until all units matched comply with their respective complex conditions. In case of internal congestion in the Iberian Market, the process is repeated using the market splitting procedure that obtains a different zonal price for Portugal and Spain, without congestion of both power systems. Both approaches make sure that no bid that implies the violation of the security limits assigned by the System Operators is matched [15].

2.4.4 Continuous Intraday Market

The Continuous Intraday Market, also named Single Intraday Coupling, SIDC, as it results from an European initiative of several Market Operators, just like the Intraday Auctions Market, allows their market participants to regulate their energy imbalances with two differences regarding its counterpart:

- **I**n addition to gaining access to local market liquidity, agents can also profit from liquidity accessible in marketplaces around Europe, every time there is enough cross-border transmission capacity between both zones.
- **T**he adjustments can be made until 1 hour before the delivery moment.

Until the Continuous Intraday Market started, in 13th June 2018, auctions were used to control import and export offers from France, using a capacity rights mechanism that had previously been gained through explicit auctions. Currently, the negotiation with France and the rest of Europe is only possible through the Continuous Intraday Market [6].

The purpose of this market is to facilitate trading energy between Europe's various zones in a continuous way, increasing the global efficiency of the intraday market transactions from all over Europe [8].

Before 27th of November 2018, there was an hybrid model in place for the Intraday Markets. Currently the definitive model is in operation and Figure 2.3 shows the negotiation periods along the day, period and time of this model. Appendix A explains in greater detail the difference between both models [6].

Table 2.3: Opening and closing times of rounds in the Continuous Intraday Market [8]

DAY	OPENING	CLOSING	ROUND	ROUNDS "D" AND "D+1"																															SESSION
D-1	14:00	15:00	17	17	18	19	20	21	22	23	24																								MI1 14:00-15:00 (1-24)
D-1	15:00	15:10	18	18	19	20	21	22	23	24																									
D-1	15:10	16:00	18	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
D-1	16:00	17:00	19	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
D-1	17:00	17:50	20	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24			
D-1	17:50	18:00	20	20																															MI2 17:00-17:50 (21-24, 1-24)
D-1	18:00	19:00	21	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
D-1	19:00	20:00	22	22	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24					
D-1	20:00	21:00	23	23	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
D-1	21:00	21:50	24	24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24							
D-1	21:50	22:00	24	24																															MI3 21:00-21:50 (1-24)
D-1	22:00	23:00	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24								
D-1	23:00	0:00	2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24									
D	0:00	1:00	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24										
D	1:00	1:50	4	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24											
D	1:50	2:00	4	4																															MI4 1:00-1:50 (5-24)
D	2:00	3:00	5	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24												
D	3:00	4:00	6	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24													
D	4:00	4:50	7	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24														
D	4:50	5:00	7	7																															MI5 4:00-4:50 (8-24)
D	5:00	6:00	8	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24															
D	6:00	7:00	9	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24																
D	7:00	8:00	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24																	
D	8:00	9:00	11	11	12	13	14	15	16	17	18	19	20	21	22	23	24																		
D	9:00	9:50	12	12	13	14	15	16	17	18	19	20	21	22	23	24																			
D	9:00	10:00	12	12																															MI6 9:00-9:50 (13-24)
D	10:00	11:00	13	13	14	15	16	17	18	19	20	21	22	23	24																				
D	11:00	12:00	14	14	15	16	17	18	19	20	21	22	23	24																					
D	12:00	13:00	15	15	16	17	18	19	20	21	22	23	24																						
D	13:00	14:00	16	16	17	18	19	20	21	22	23	24																							

Contracts are products with a specific start and end time applied, assigned to each delivery hour, which are open to negotiation at any given time.

The negotiation of one or several contracts will be done in different time periods called "Rounds". These rounds will have an opening time equal to the closing time of the previous round, and a closing time that is associated with the closing of a contract in the European Platform. In the MIBEL, rounds start at the beginning of each hour of the day [15].

2.4.4.1 Single Intraday Coupling

XBID, Cross-Border Intraday Market Project, is a program that was developed as a joint initiative by System Operators from 11 countries, to create a coupled integrated intraday cross-border market with the objective of allowing electric energy trading in a continuous way and between different zones across Europe, now known as Single Intraday Coupling, SIDC [15, 16, 17].

Currently the countries that have embraced this program are shown in Figure 2.5.

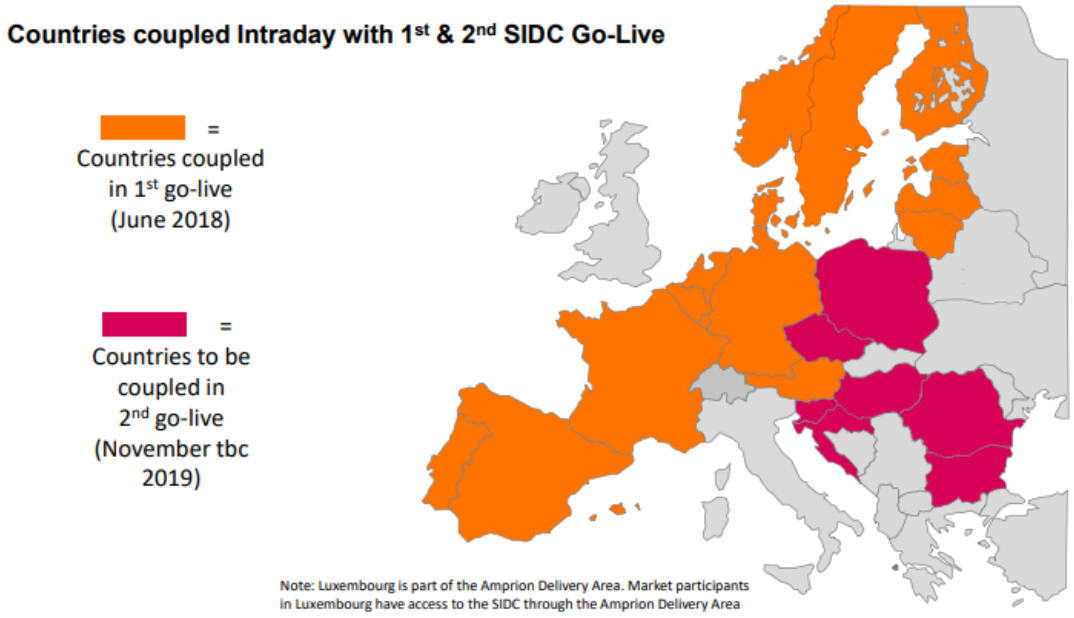

Figure 2.5: Countries coupled Intraday with 1st & 2nd SIDC Go-Live [5]

This solution is based on a common IT system with a Shared Order Book (SOB), a Capacity Management Module (CMM) and a Shipping Module (SM) in which all local intraday markets are connected. This allows bids that are inserted in a market from a certain country to be matched with a bid from any other country connected to the system, in case there is enough transmission capacity available between both countries [15, 16].

This connection of the intraday markets [18, 5]:

- Benefits cross-border intraday trading opportunity across Europe on a harmonised platform.
- Develops a better optimization of the usage of generation, especially from renewable sources.
- Enables demand response products to develop.
- Brings the whole European Intraday continuous markets together complementing the existing Day-ahead market.
- Allows for a wide variety of product range - 15 minutes, 30 minutes, hourly, block products.
- Supports a wide range of contract types.
- Supports a wide range of order types:
  - Iceberg-enabled
  - Link-enabled
  - Block-order-enabled

The negotiation platform groups all bids in a Shared Order Book (SOB), by order of arrival, available to all market participants if the interconnection capacity is enough, and matches the

bids that are being added to the SOB with the already existing ones in the most competitive way possible, following the price-time-capacity criteria:

- **Price:** bids will always be paired with the ones that have the most competitive price.
- **Time:** in case there are two bids with the same price, the older one is prioritized.
- **Capacity:** there must be enough transmission capacity available for the matching to be done [5].

The Capacity Management Module (CMM) is designed as a web solution, continuously managing the updates of the capacity available in each border between market areas. It is in constant communication with SOB to keep its values updated at each moment so that this capacity can be negotiated implicitly in the continuous market. It also allows agents to explicitly negotiate the capacity available of the borders that allow it [5, 19].

The Shipping Module (SM) receives data from all completed transactions in SOB:

- Between two different market areas;
- Or in the same area but with two different Exchange Members.

This means that this module is in charge of collecting information from SOB, CMM and the System Operators in a filtered way so that it can transfer the most relevant pieces to the interested parties [5].

2.4.4.2 Presentation of Bids to the Continuous Intraday Market

Bids in the MIBEL have to be sent through the OMIE Trading Platform, Local Trading Solution (LTS), in order to participate in the Continuous Intraday Market. All available orders in the Order Book that have not yet been matched due to the lack of competitiveness of their price will appear in it. These orders may be from the same area or from a different one in Europe depending on the available interconnection capacity between the involved countries. Each bid will be established for a given contract and will include a price and volume, as well as expressing bid or portfolio units [15].

Bids can be sent to one or several contracts and must fulfill all system validations, shown below. In case there is a bid that does not meet those requirements, it will be rejected. Furthermore the economic value of the bid must not exceed the operational limit set by the agent in the OMIE platform, and if shared, all owning agents must have a sufficient operational limit to support 100% of the offer owned by them [15].

In order to validate the bid that is inserted, OMIE will have to validate the Unavailability and the Limitations sent by the System Operators. In other words, by sending a bid, the sum of the energy volume, plus the previous program PHFC, plus the transactions made during the current round, plus the bids stored in the SOB, must be below the maximum and above the minimum stipulated by the System Operators [15].

The following execution conditions may apply when submitting bids to the Continuous Intraday Market:

- **NONE (NON)** — they can be matched immediately or partially, being that in this last case, the quantity that is not matched will remain in the Order Book at the same price. Being canceled if not matched by the end of the contract.
- **Immediate or cancel (IOC)** — they will be matched with the most competitive bids in the Order Book in case the prices are acceptable. It can be matched partially but the remaining quantity that is not matched will be eliminated from the Order Book.
- **Fill or Kill (FoK)** — these bids can't be matched partially, and if not entirely matched the offer is completely removed.
- **Iceberg** — besides expressing the amount of energy that an agent wants to buy/sell, it also adds a reduced part of that quantity that is to be shown in the Order Book. Meaning that if the first amount that was shown is matched, a new offer with the same specifications will appear in the Order Book.
- **Iceberg with price increase** — in case a price increase is submitted, at each instance there will be a new price that is equal to the price of the previous instance plus the price increase. Similar to the one above, but this time the new offer will have an increase in price set by the agent [20].

In addition, the following orders validity conditions may apply:

- **Good-For-Session (GFS)** — tids will be valid until the end of the respective contract, being that all bids will have this option by default;
- **Good-Till-Date (GTD)** — they will be valid until a determined time period set by the agent, always before the closing of that specific contract [20].

Similarly to the Day-Ahead Market and the Intraday Auctions Market, the maximum and minimum price limits for the Continuous Intraday Market were changed. But this time, in the analysis presented in chapter 3, there were negative prices registered for the first time in December 2019 and for several months of 2020 [13].

In addition, agents can create a basket with multiple offers (Basket Orders) that can be associated with different contracts. Basket Orders imply a simultaneous process of all bids included in the basket. Depending on the parameters set by the agent for that basket, these bids may or may not be matched independently of one another.Each of the basket's offers may have terms and limitations for order execution and/or validity [15].

2.4.4.3 Matching Process in the Continuous Intraday Market

All offers will be sent through the LTS of each Market Operator. When the offers are validated, they will then be sent to SIDC and stored in the SOB where they will be later matched or discarded. In case of matching, the result will be communicated to the agent, and also updated in the local Order Book [15].

SIDC transactions will be firm, which means that if the offer is a purchase order, it will indicate a commitment to buy the product. If the order is for a sale, it will imply a delivery duty as well as the right to collect at the transaction's price [15].

Chapter 3

Analysis of the energy prices

3.1 Introduction

The Intraday Auctions Market and the Continuous Intraday Market, addressed in greater detail in Chapter 2, are platforms that complement the Day-Ahead Market allowing agents to adjust the program that resulted from the Day-Ahead Market closer to real-time needs, by submitting new energy offers in the six different sessions or continuously throughout the day.

In this chapter, the results for all three markets regarding energy prices are analysed for each year from 2018 until 2020. Firstly, each year are analysed separately and then they will be put together for a general analysis. In order to have a better comparison of the average prices, the data used for all three markets starts at the same point in time, the creation of the Continuous Intraday Market, 13th of June 2018. The month of August was chosen for the analysis of the average price per day due to the fact that it is a month with data from all markets for all three years in study and that it contains an holiday in both Portugal and Spain, making it an interesting month to analyse.

Unless specified otherwise, the Intraday Auctions Markets values are an average of the hourly prices in all six sessions, and the Continuous Intraday Market values are the average prices that resulted from all rounds containing that specific hour in their negotiation period.

The values used throughout this chapter are a weighted average between Portugal and Spain values in order to obtain a value that is acceptable for the Iberian Market as a whole. These average values were calculated using the Equation 3.1.

$$MIBEL_{price} = PT_{price} \times \frac{PT_{volume}}{MIBEL_{volume}} + ES_{price} \times \frac{ES_{volume}}{MIBEL_{volume}} \tag{3.1}$$

$$MIBEL_{volume} = PT_{volume} + ES_{volume} \tag{3.2}$$

In which:

- $MIBEL_{price}$ is the established price for the Iberian Market through a weighted average of both Portuguese and Spanish Market prices;

- $MIBEL_{volume}$ is the total of volume of energy traded in the Iberian Market;
- PT_{price} is the price set for Portugal;
- PT_{volume} is the volume of energy traded in Portugal;
- ES_{price} is the price set for Spain;
- ES_{volume} is the volume of energy traded in Spain.

For this analysis it is necessary to download the data publicly available at the web page of the Iberian Market Operator, OMIE, which can be found in the following references [21, 22]. INESC-TEC provided a means to download this data into spreadsheet format for it to be further processed with the help of Microsoft Excel and its Power Query feature.

3.2 Average prices of 2018

The average energy price in 2018 was 63.79 €/MWh for the Day-Ahead Market, 64,31 €/MWh for the Intraday Auctions Market and 63,22 €/MWh for the Continuous Intraday Market. Figure 3.1 represents those three prices.

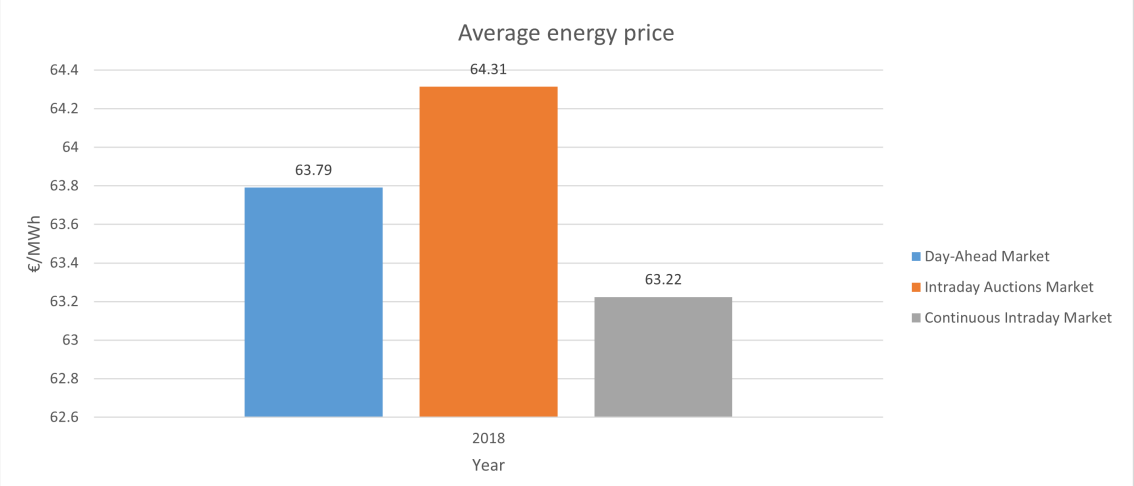

Figure 3.1: Average energy prices of all three markets for the year of 2018

3.2.1 Average price per month

The graphic shown in Figure 3.2 represents the average energy prices per month in 2018. To complement this graphic, Table 3.1 shows the calculated deviations of each of the Intraday Markets to the Day-Ahead Market.

Figure 3.2: Average energy prices per month of all three markets for the year of 2018

Table 3.1: Average energy prices per month and the deviations of the Intraday Auctions Market and the Continuous Intraday Market from the Day-Ahead Market in 2018, values in €/MWh

	Day-Ahead Market	Intraday Auctions Market	Continuous Intraday Market	Deviation of IAM	Deviation of CIM
Month	2018				
6	57.93	57.73	57.42	0.20	0.51
7	61.85	62.11	61.90	0.26	0.05
8	64.32	64.90	64.11	0.58	0.21
9	71.28	72.56	71.58	1.28	0.30
10	65.15	65.53	64.13	0.38	1.02
11	61.98	62.69	60.83	0.71	1.15
12	61.82	62.10	59.82	0.28	2.00

It is possible to observe that the Intraday Auctions Market records its biggest deviation from the Day-Ahead Market in September of 1.28 €/MWh. On the other hand the Continuous Intraday Market deviation starts increasing in October, reaching its peak of 2.00€/MWh in December.

3.2.2 Average price per day

In order to observe the difference in prices between weekdays, weekends and holidays, Figure 3.3 shows the evolution of the average prices per day in August. Weekends are marked as grey zones, while the holiday, 15th of August, is marked as a green bar.

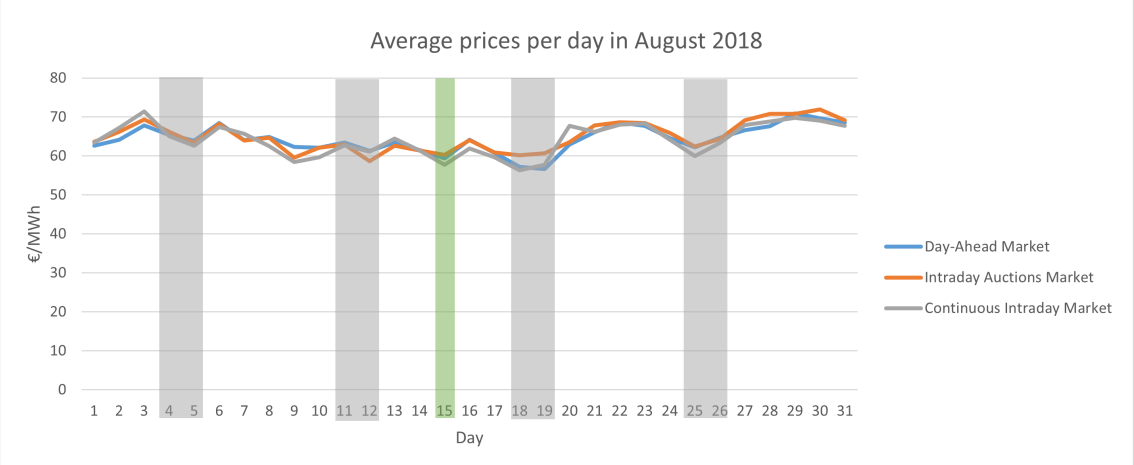

Figure 3.3: Evolution of the average energy prices per day of all three markets for August 2018

The average energy price for the month of August was 64.32 €/MWh for the Day-Ahead Market, 64.90 €/MWh for the Intraday Auctions Market and 64.11 €/MWh for the Continuous Intraday Market. It is possible to observe that the evolution of average prices follows the trend of the evolution of energy traded for those days. In the work days where the energy demand was larger, the prices followed. On the other hand, on weekends and holidays, when the demand for energy was at its bottom, the prices were also the lowest.

3.2.3 Average price per hour

Figure 3.4 shows a graphic where for each hour and for each market that was analysed, the value in the graph corresponds to the average value of the prices in that hour in the different days of the period under analysis.

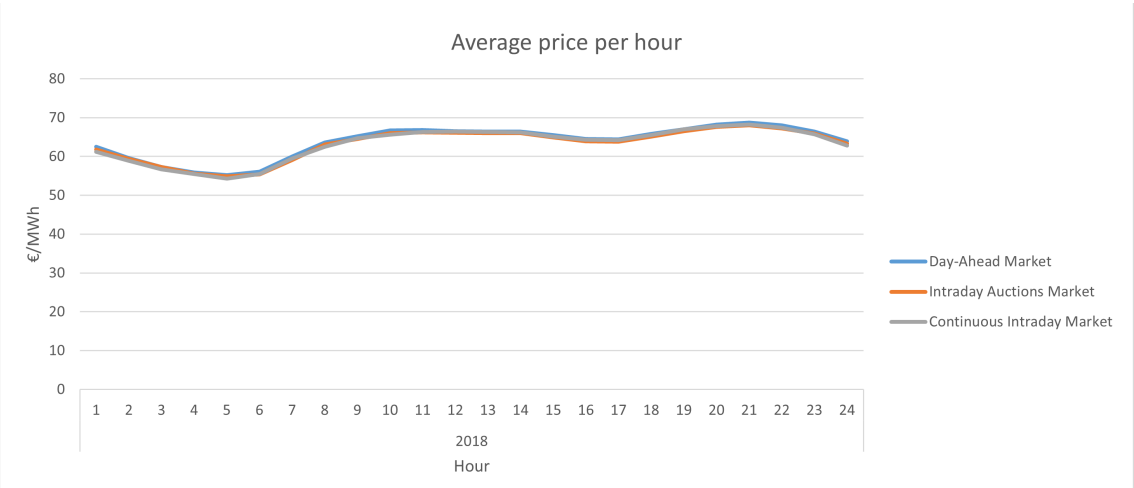

Figure 3.4: Average energy prices per hour of all three markets for 2018

It is possible to observe that both Intraday Markets are almost equal to the Day-Ahead Market with no visible relevant deviation. The average hourly prices were 63.79 €/MWh for the

Day-Ahead Market, 64.32 €/MWh for the Intraday Auctions Market and 63.23 €/MWh for the Continuous Intraday Market resulting in a maximum deviation from the Day-Ahead Market of 0.56 €/MWh.

3.2.4 Average price per session or round

The Intraday Auctions Market is divided in six sessions with different scheduled horizons. Figure 3.5 and Table 3.2 represent the average energy prices per session for 2018.

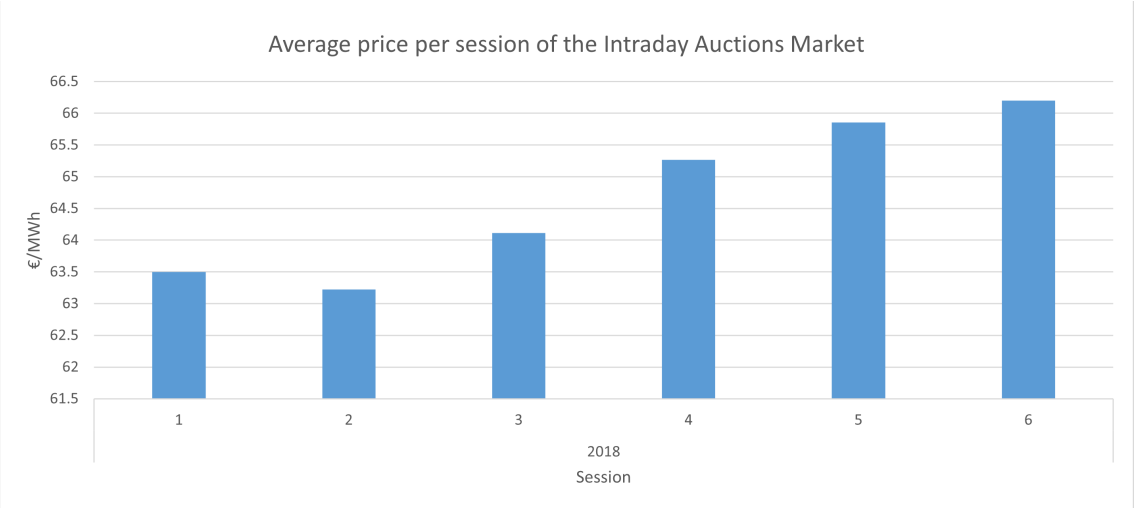

Figure 3.5: Evolution of the average energy prices per session of the Intraday Auctions Market for 2018

Table 3.2: Average energy prices per session of the Intraday Auctions Market for 2018, values in €/MWh

Session	Intraday Auctions Market
1	63.50
2	63.22
3	64.11
4	65.27
5	65.86
6	66.20

Sessions 5 and 6 have the larger prices due to being closer to the delivery time of the hours of the day with the highest energy demand and lower liquidity in the Intraday Auctions Market.

On the same note, the Continuous Intraday Market is divided in twenty four sessions, called rounds, and their average energy price is represented in Figure 3.6.

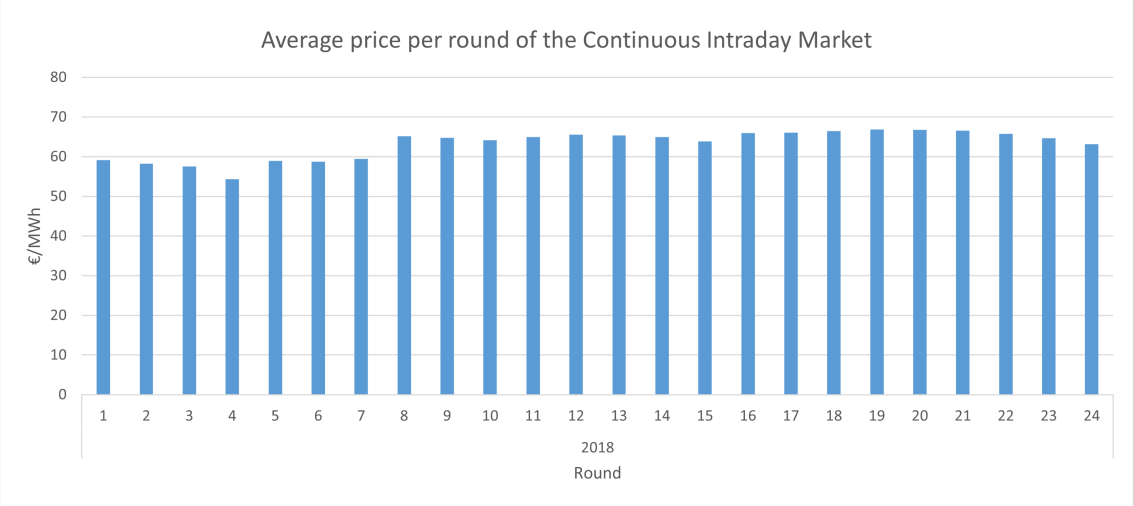

Figure 3.6: Evolution of the average energy prices per round of the Continuous Intraday Market for 2018

It is possible to observe that the average price per round does not differ much from the trend of the average hourly price of the Continuous Intraday Market, visible in Figure 3.4.

3.3 Average prices of 2019

The average energy price in 2019 was 47.73 €/MWh for the Day-Ahead Market, 48.05 €/MWh for the Intraday Auctions Market and 47.24 €/MWh for the Continuous Intraday Market. Figure 3.7 represents those three prices.

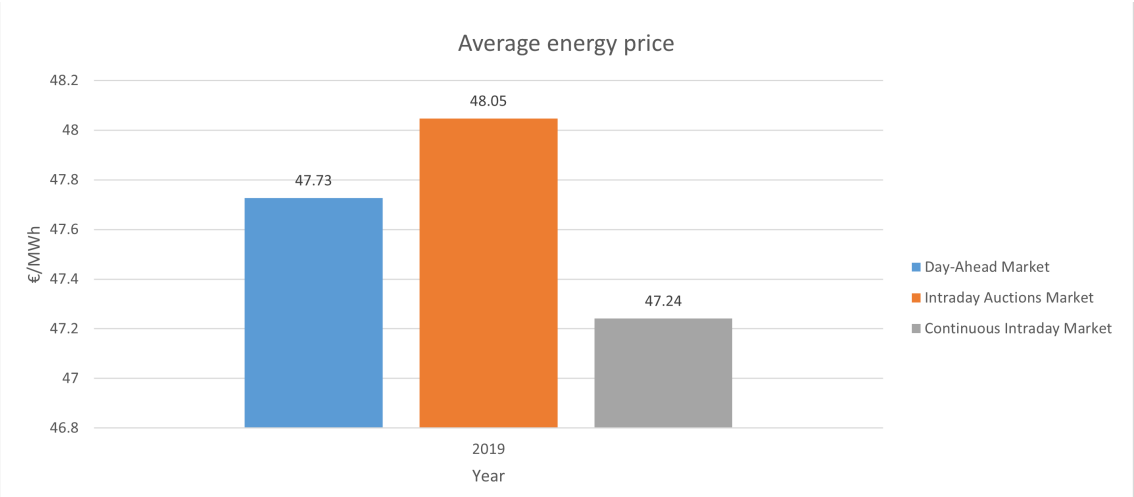

Figure 3.7: Average energy prices of all three markets for the year of 2019

The prices of each market decreased in comparison with 2018, due to the fact that 2019 had a lower value of energy consumption. Each market still follows the same trend of the previous year,

with the Intraday Auctions Market having the largest price and the Continuous Intraday Market the lowest.

3.3.1 Average price per month

The graphic shown in Figure 3.7 represents the average energy prices per month in 2019. To complement this graphic, Table 3.3 shows the calculated deviations from the Day-Ahead Market for each of the Intraday Markets.

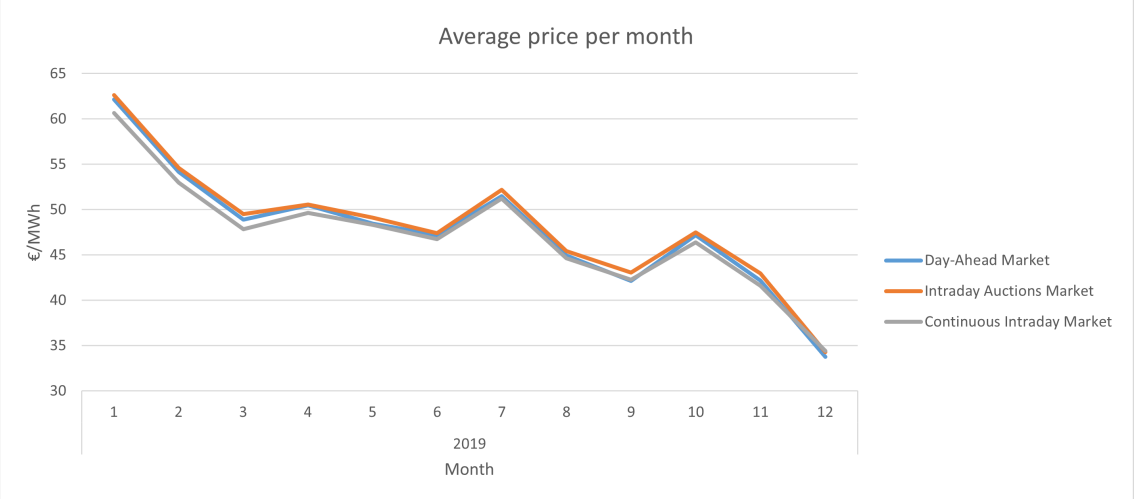

Figure 3.8: Average energy prices per month of all three markets for the year of 2019

Table 3.3: Average energy prices per month and the deviations of the Intraday Auctions Market and the Continuous Intraday Market from the Day-Ahead Market in 2019, values in €/MWh

	Day-Ahead Market	Intraday Auctions Market	Continuous Intraday Market	Deviation of IAM	Deviation of CIM
Month	2019				
1	62.16	62.62	60.66	0.47	1.50
2	54.17	54.60	52.96	0.42	1.22
3	48.91	49.50	47.84	0.59	1.07
4	50.47	50.57	49.65	0.10	0.82
5	48.47	49.10	48.31	0.63	0.16
6	47.20	47.40	46.75	0.21	0.45
7	51.46	52.18	51.23	0.72	0.23
8	44.96	45.42	44.64	0.46	0.32
9	42.12	43.06	42.28	0.94	0.16
10	47.18	47.47	46.40	0.30	0.78
11	42.18	42.95	41.61	0.78	0.56
12	33.78	34.30	34.40	0.52	0.63

It is possible to observe that the Intraday Auctions Market records its largest deviation from the Day-Ahead Market in September of 0.94 €/MWh, while the Continuous Intraday Market had its biggest deviations in the beginning of the year, recording its maximum deviation of 1.50 €/MWh in January.

3.3.2 Average price per day

Just like in 2018, in order to observe the price differences between weekdays, weekends and holidays, Figure 3.9 shows the evolution of the average prices per day in August. Weekends are marked as grey zones, while the holiday, 15th of August, is marked as a green bar.

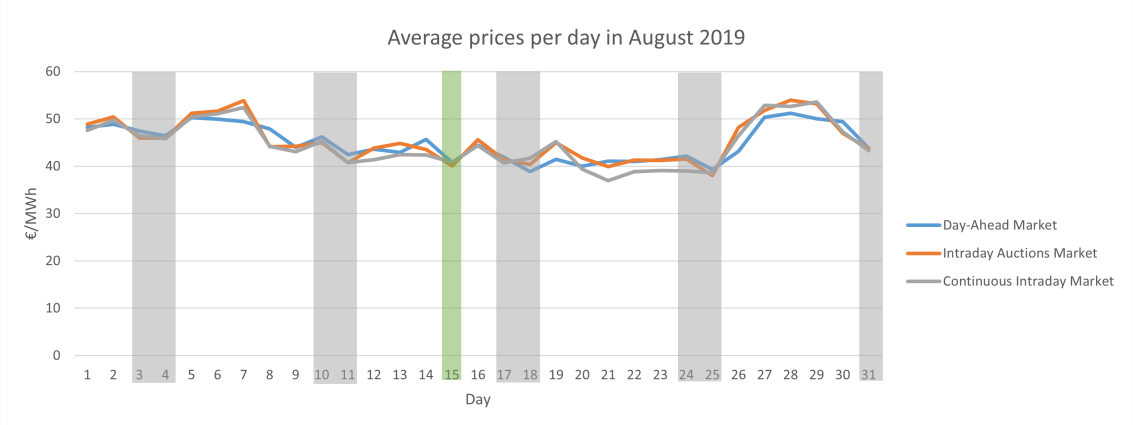

Figure 3.9: Evolution of the average energy prices per day of all three markets for August 2019

The average energy price for the month of August was 44.96 €/MWh for the Day-Ahead Market, 45.42 €/MWh for the Intraday Auctions Market and 44.64 €/MWh for the Continuous Intraday Market. As it was already expected, the evolution of average prices follows the trend of the evolution of energy traded for those days. So just like in 2018 the work days where the energy demand was larger the prices followed. On the other hand, on weekends and holidays, when the demand for energy was at its bottom, the prices were also more reduced.

3.3.3 Average price per hour

It is possible to observe the average hourly prices of 2019 for all three markets in Figure 3.10.

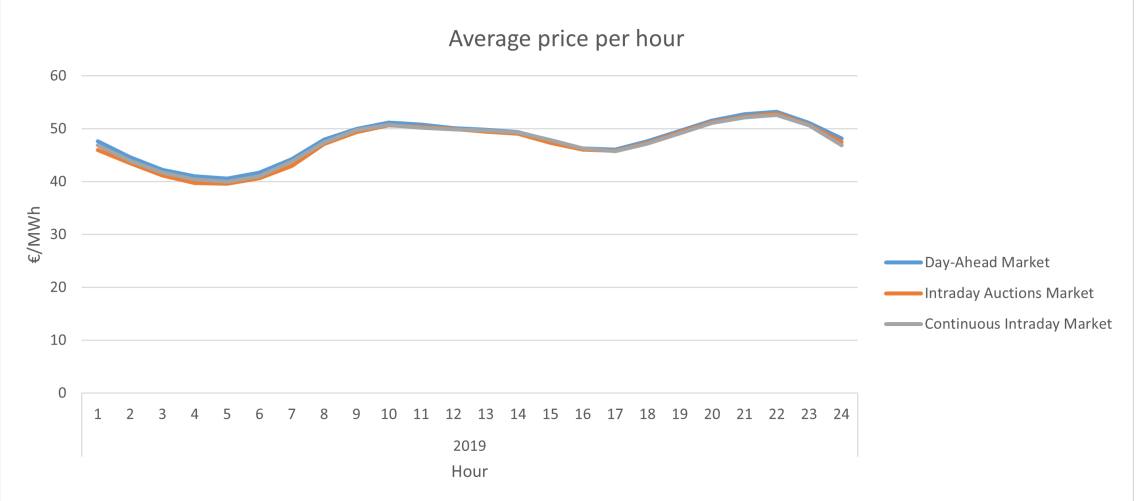

Figure 3.10: Average energy prices per hour of all three markets for 2019

Similarly to 2018, both Intraday Markets follow the trend of the Day-Ahead Market with no visible relevant deviation. The average hourly prices were 47.73 €/MWh for the Day-Ahead Market, 48.05 €/MWh for the Intraday Auctions Market and 47.24 €/MWh for the Continuous Intraday Market resulting in a maximum deviation from the Day-Ahead Market of 0.51 €/MWh.

3.3.4 Average price per session or round

Figure 3.11 and Table 3.4 represent the average energy prices per session for 2019.

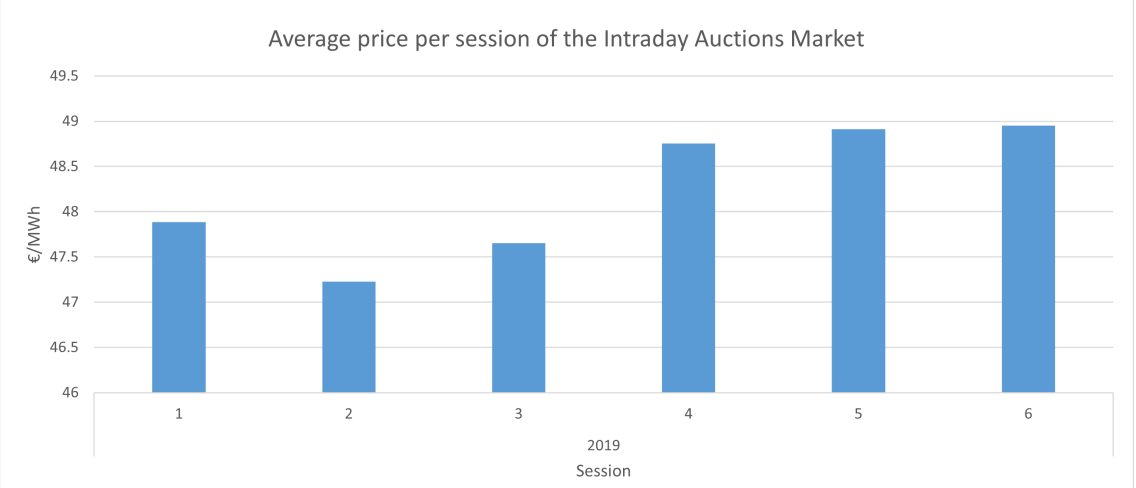

Figure 3.11: Evolution of the average energy prices per session of the Intraday Auctions Market for 2019

Table 3.4: Average energy prices per session of the Intraday Auctions Market for 2019, values in €/MWh

Session	Intraday Auctions Market
1	47.89
2	47.23
3	47.65
4	48.75
5	48.91
6	48.95

Once again, sessions 5 and 6 have the larger prices due to being closer to the delivery time of the hours of the day with the highest energy demand and with lower liquidity.

On the same note, the Continuous Intraday Market average energy price per round is represented in Figure 3.12.

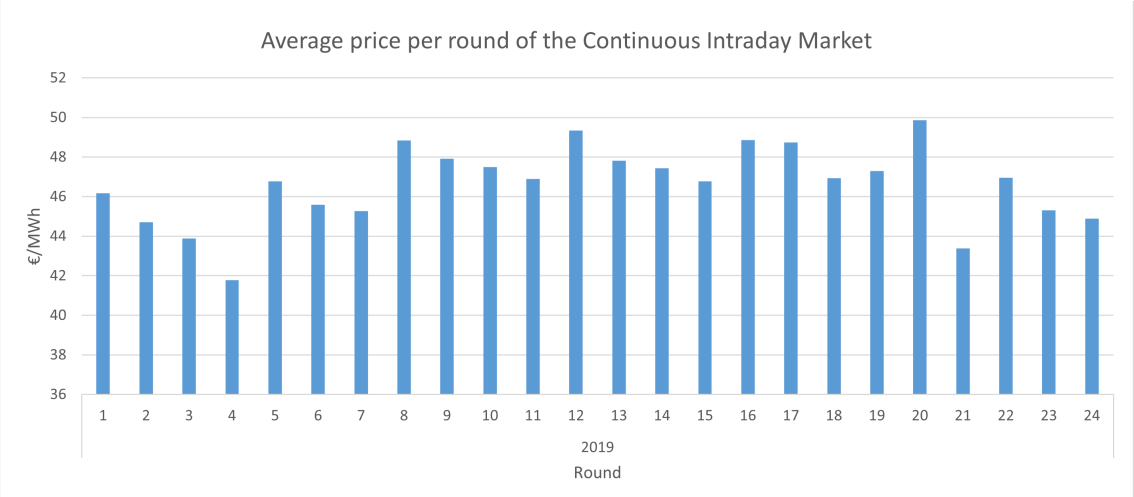

Figure 3.12: Evolution of the average energy prices per round of the Continuous Intraday Market for 2019

Through the graphic in Figure 3.12 we can observe a trend in which prices go up in the round with opening time equal to the beginning of the Intraday Auction Market sessions, decreasing steadily in the following rounds.

3.4 Average prices of 2020

The average energy price in 2020 was 33.96€/MWh for the Day-Ahead Market, 34.47€/MWh for the Intraday Auctions Market and 33.68€/MWh for the Continuous Intraday Market. Figure 3.13 represents those three prices.

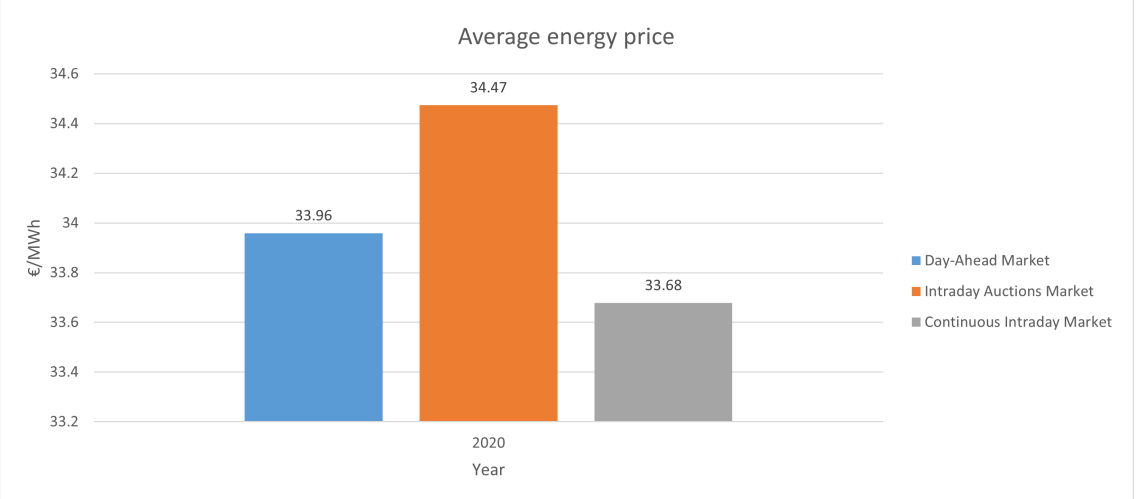

Figure 3.13: Average energy prices of all three markets for the year of 2020

As illustrated in Figure 3.13, once again there was a decrease in price for all three markets in comparison with previous years, due to an increase in renewable energy generation and decrease in overall consumption demand.

3.4.1 Average price per month

The average energy prices per month in 2020 can be seen through the graphic shown in Figure 3.13. To complement this graphic, Table 3.5 shows the calculated deviations from the Day-Ahead Market for each of the Intraday Markets.

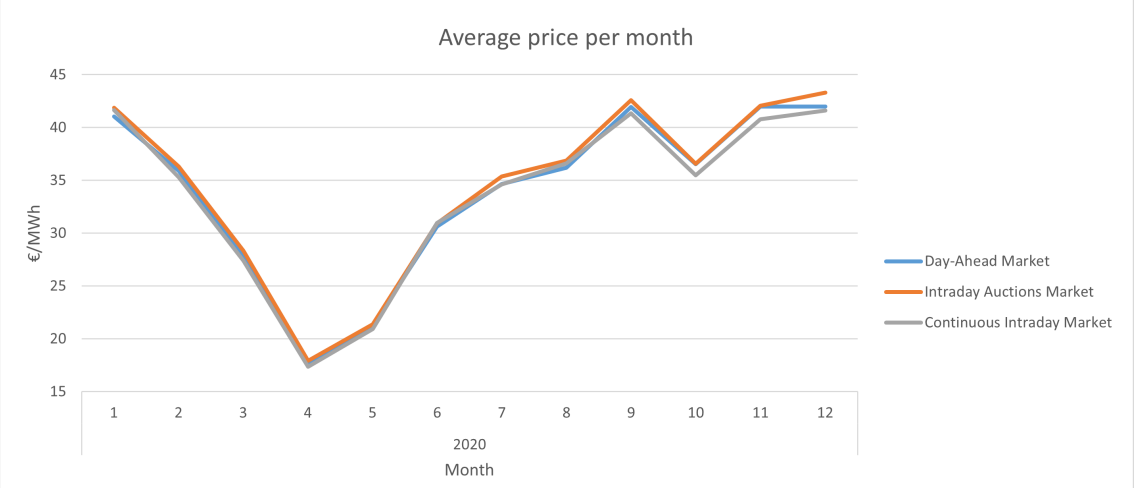

Figure 3.14: Average energy prices per month of all three markets for the year of 2020

Table 3.5: Average energy prices per month and the deviations of the Intraday Auctions Market and the Continuous Intraday Market from the Day-Ahead Market in 2020, values in €/MWh

	Day-Ahead Market	Intraday Auctions Market	Continuous Intraday Market	Deviation of IAM	Deviation of CIM
Month	2020				
1	41.06	41.86	41.66	0.80	0.60
2	35.91	36.30	35.30	0.39	0.61
3	27.76	28.35	27.41	0.59	0.35
4	17.68	17.93	17.37	0.25	0.31
5	21.28	21.40	20.93	0.12	0.35
6	30.62	30.93	30.98	0.31	0.35
7	34.64	35.38	34.62	0.75	0.01
8	36.18	36.86	36.59	0.68	0.41
9	41.95	42.58	41.35	0.63	0.60
10	36.53	36.58	35.48	0.05	1.06
11	41.97	42.07	40.80	0.10	1.18
12	41.98	43.32	41.60	1.34	0.38

It is possible to observe that the Intraday Auctions Market has its larger deviation from the Day-Ahead Market in December of 1.34 €/MWh, while the Continuous Intraday Market had its biggest deviations towards the end of the year, recording its maximum deviation of 1.18 €/MWh in November.

3.4.2 Average price per day

Similarly to 2018 and 2019, in order to observe the difference in prices between weekdays, weekends and holidays, Figure 3.15 shows the evolution of the average prices per day in August. Weekends are marked as grey zones, while the holiday, 15th of August, is marked as a green bar.

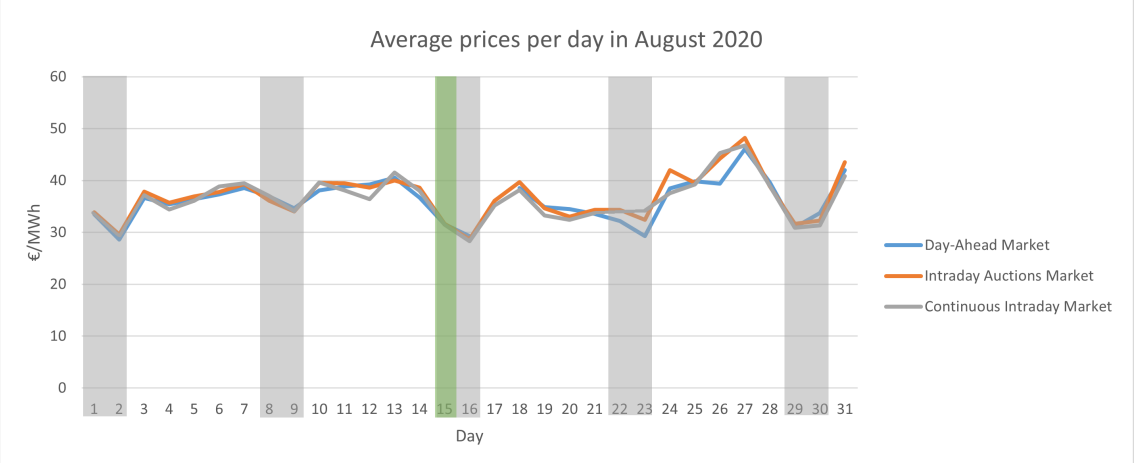

Figure 3.15: Evolution of the average energy prices per day of all three markets for August 2020

The average energy price for the month of August was 36.18 €/MWh for the Day-Ahead Market, 36.86 €/MWh for the Intraday Auctions Market and 36.59 €/MWh for the Continuous Intraday Market. These prices follow the same trend as in previous years described in their respective sub chapters.

3.4.3 Average price per hour

Figure 3.16 shows a graphic with the average hourly prices of 2020 for the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market.

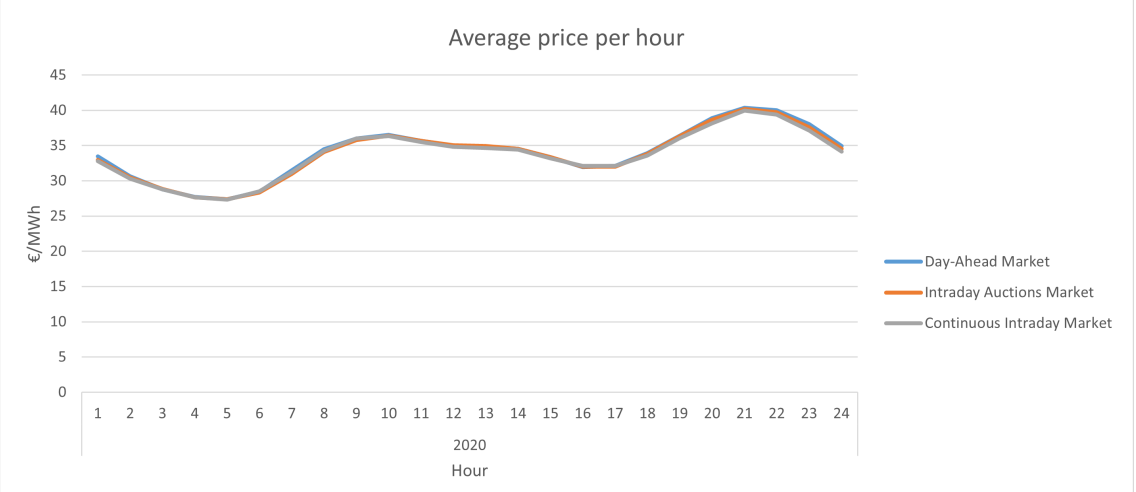

Figure 3.16: Average energy prices per hour of all three markets for 2020

It is possible to observe that both Intraday Markets follow the trend of the Day-Ahead Market with no visible relevant deviation. The average hourly prices were 33.96€/MWh for the Day-Ahead Market, 34.48€/MWh for the Intraday Auctions Market and 33.68€/MWh for the

Continuous Intraday Market resulting in a maximum deviation from the Day-Ahead Market of 0.52€/MWh.

3.4.4 Average price per session or round

Figure 3.17 and Table 3.6 represent the average energy prices per session for 2020.

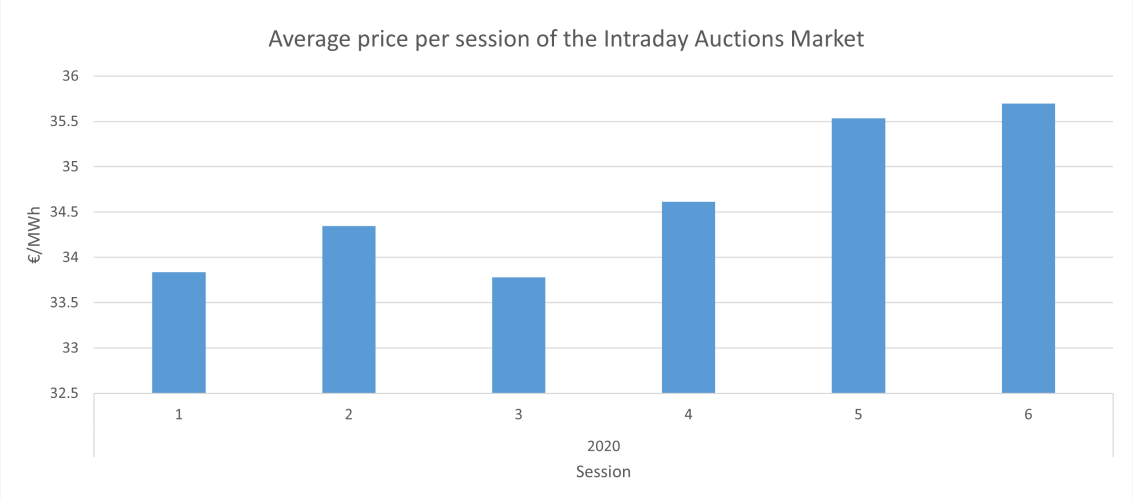

Figure 3.17: Evolution of the average energy prices per session of the Intraday Auctions Market for 2020

Table 3.6: Average energy prices per session of the Intraday Auctions Market for 2020, values in €/MWh

Session	Intraday Auctions Market
1	33.84
2	34.35
3	33.78
4	34.61
5	35.54
6	35.70

Once again, sessions 5 and 6 represent the larger prices, though this time session 2 has an increase in price, surpassing even session 1 which may be due to the change in scheduled horizons that led to a shift in energy traded between both sessions.

The Continuous Intraday Market average energy price per round is represented in Figure 3.18.

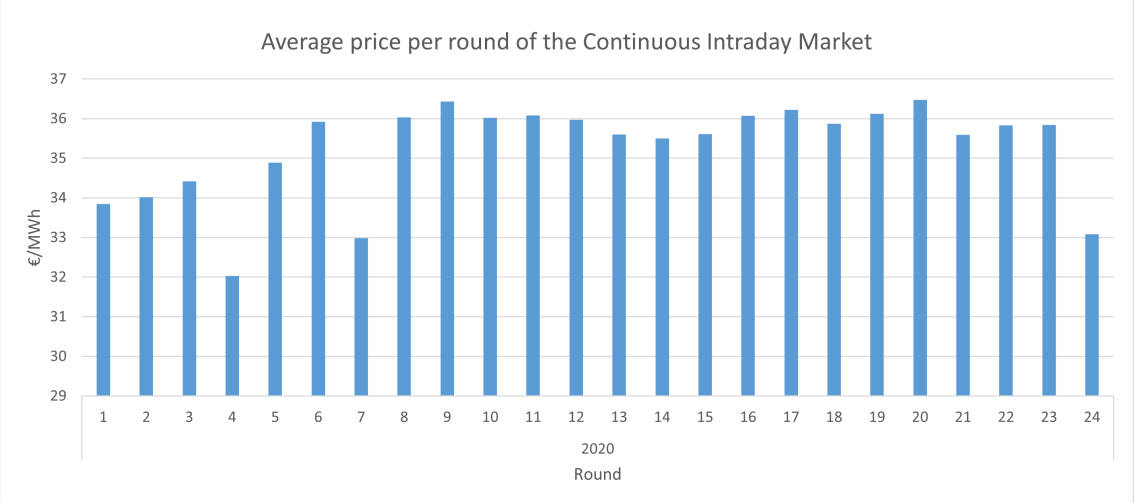

Figure 3.18: Evolution of the average energy prices per round of the Continuous Intraday Market for 2020

Through the graphic in Figure 3.18 we can observe that this time, the prices went back to following the trend of the average hourly price of the Continuous Intraday Market, with the exception of rounds 4, 7 and 24.

3.5 General analysis of all three years

Figure 3.19 shows the evolution of the average energy prices of each market throughout the years, where it is possible to observe that the Intraday Auctions Market can be considered the most expensive market. On the other hand, its counterpart, the Continuous Intraday Market, can be considered the cheapest market.

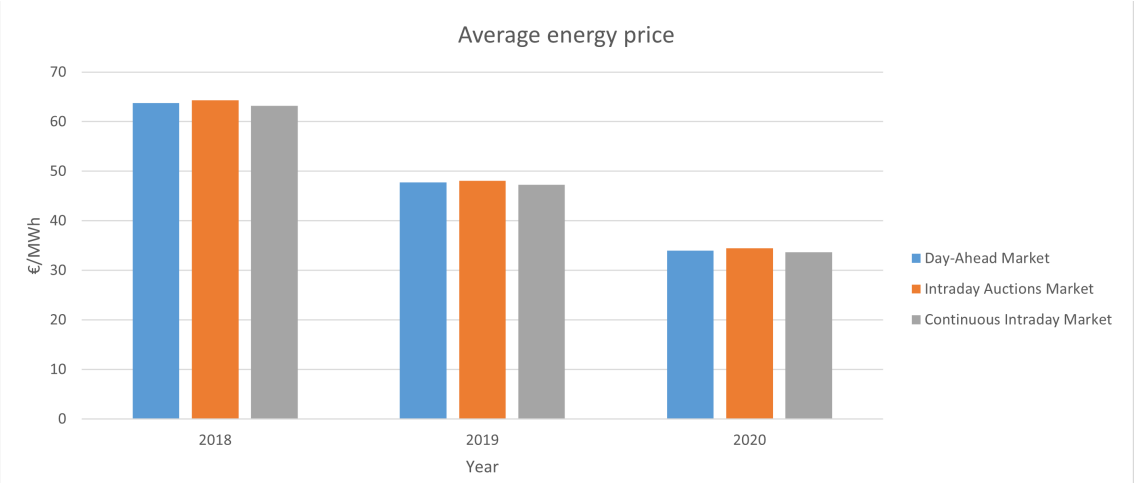

Figure 3.19: Evolution of the average energy prices of each market for 2018, 2019 and 2020

Table 3.7 represents the values used for Figure 3.19.

Table 3.7: Average energy prices for the years of 2018, 2019 and 2019 of each market, values in €/MWh

	Day-Ahead Market	Intraday Auctions Market	Continuous Intraday Market
2018	63.79	64.31	63.22
2019	47.73	48.05	47.24
2020	33.96	34.47	33.68

3.5.1 Monthly analysis

Figure 3.20 illustrates the evolution of average monthly prices throughout the years for the Day-Ahead and both Intraday markets.

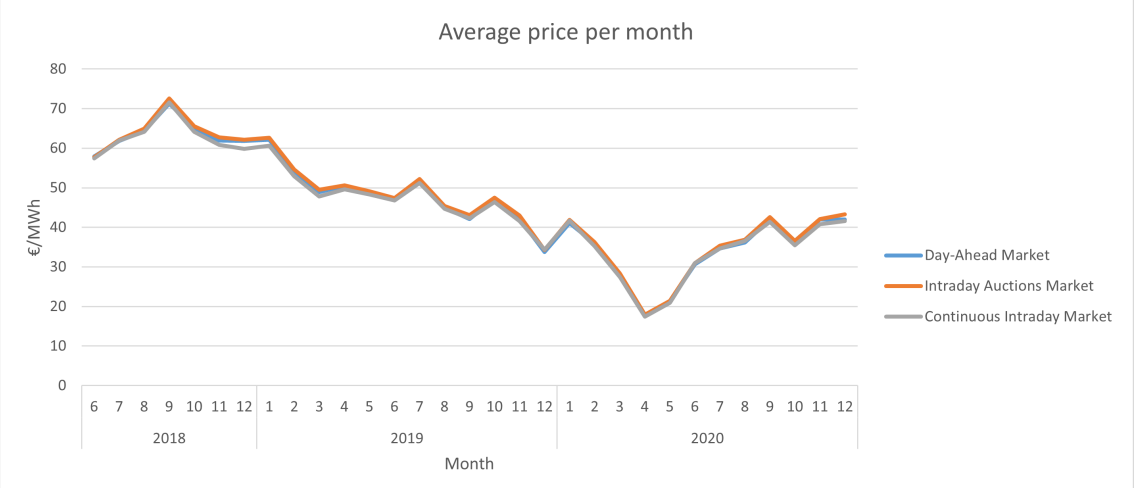

Figure 3.20: Evolution of the monthly average energy prices of each market for 2018, 2019 and 2020

It is possible to observe a major decrease in average monthly energy prices in March 2020 that can be explained due to the worldwide crisis, COVID-19 pandemic, that led to an emergency state in the Iberian Peninsula. A lockdown was issued resulting in the temporary closure of most industries which meant a decrease in demand for energy resulting in lower prices.

3.5.2 Hourly analysis

Over 2018, 2019 and 2020, the average hourly prices of both Intraday Markets followed the trend of the Day-Ahead Market average hourly prices. Figure 3.21 represents the average hourly prices of each market over all three years.

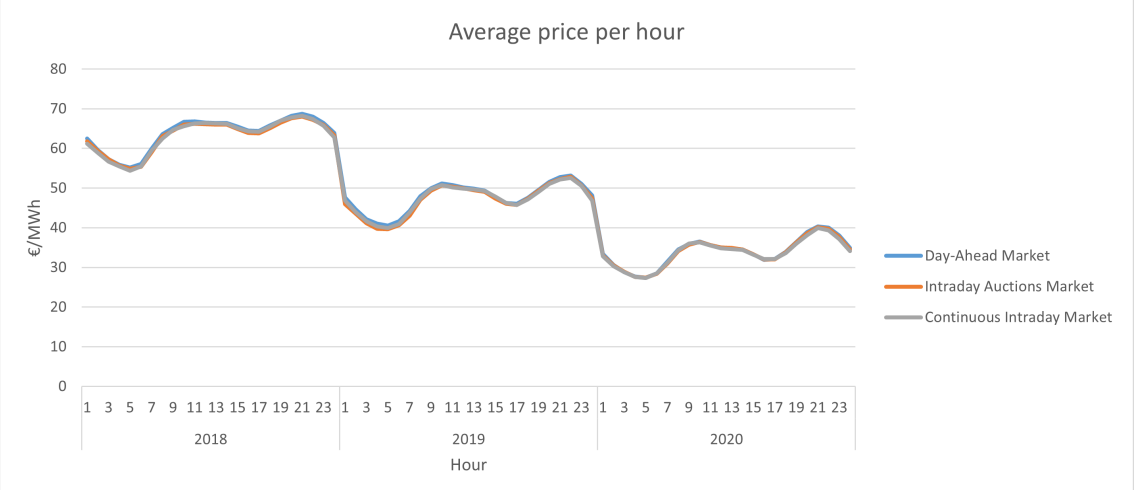

Figure 3.21: Evolution of the hourly average energy prices of each market for 2018, 2019 and 2020

The average hourly prices of each Intraday Market are almost equal to the Day-Ahead Market average price with no visible relevant deviation. Meaning that to get a rough idea of how the Intraday Market prices will behave, one can take a guess from looking at the Day-Ahead Market prices.

3.5.3 Analysis on sessions and rounds

As mentioned while analysing each year separately, sessions 5 and 6 of the Intraday Auctions Market were the ones that recorded the highest average prices due to being the sessions closer to the hours where there is more demand and lower liquidity. In 2020 there was also a noticeable difference in the average price of session 2 that resulted from a change in the schedule horizons where session 2 became the session with the longest scheduled horizon of 28 hours, increasing its average price, this change occurred in 12th of November 2019. Figure 3.22 shows the average prices per session for all three years.

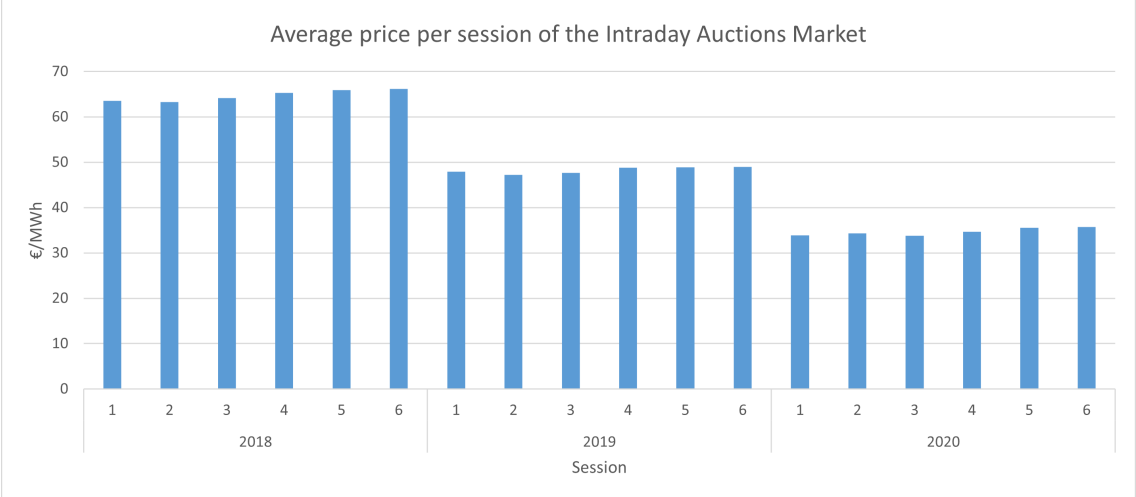

Figure 3.22: Evolution of the average energy prices per session of the Intraday Auctions Market for 2018, 2019 and 2020

For the Continuous Intraday Market, the price per round usually followed the average hourly price of the market with the exception of 2019 where the rounds prior to the Intraday Auctions Market sessions were the ones that recorded the highest prices, steadily decreasing for the following hours. Also for 2020 there were three rounds that did not follow this behavior and recorded lower average prices. The average price per round for all three years can be observed in Figure 3.23

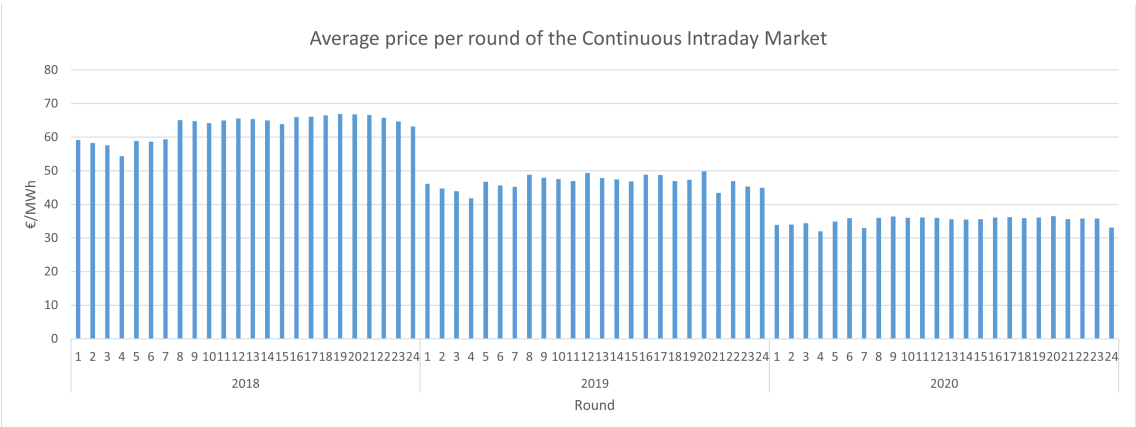

Figure 3.23: Evolution of the average energy prices per round of the Continuous Intraday Market for 2018, 2019 and 2020

3.5.4 Minimum and maximum prices

Finally, in Figures 3.24 and 3.25 we can observe the evolution of the minimum and maximum prices of each market respectively.

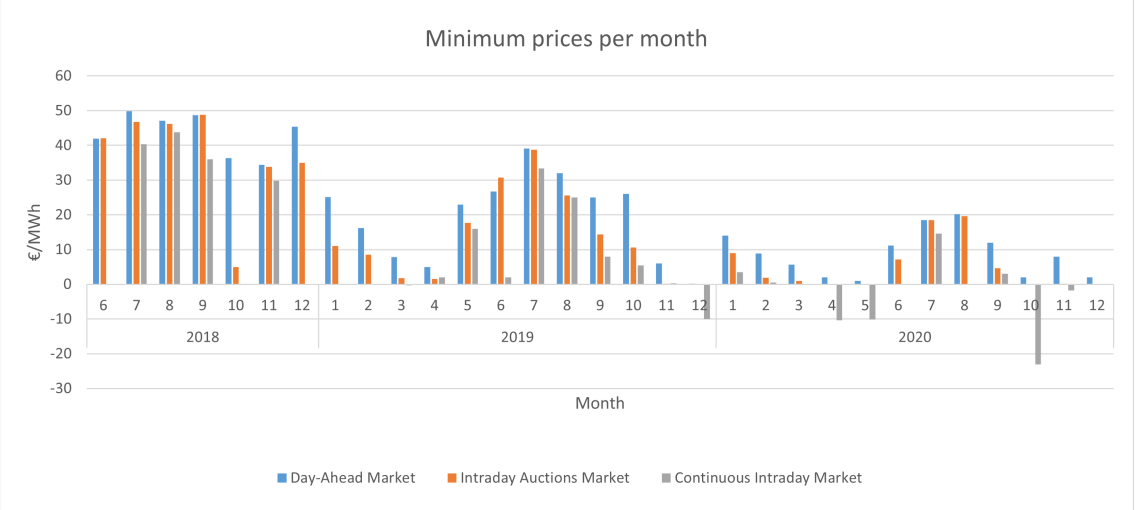

Figure 3.24: Evolution of the minimum energy prices per month of all three markets for 2018, 2019 and 2020

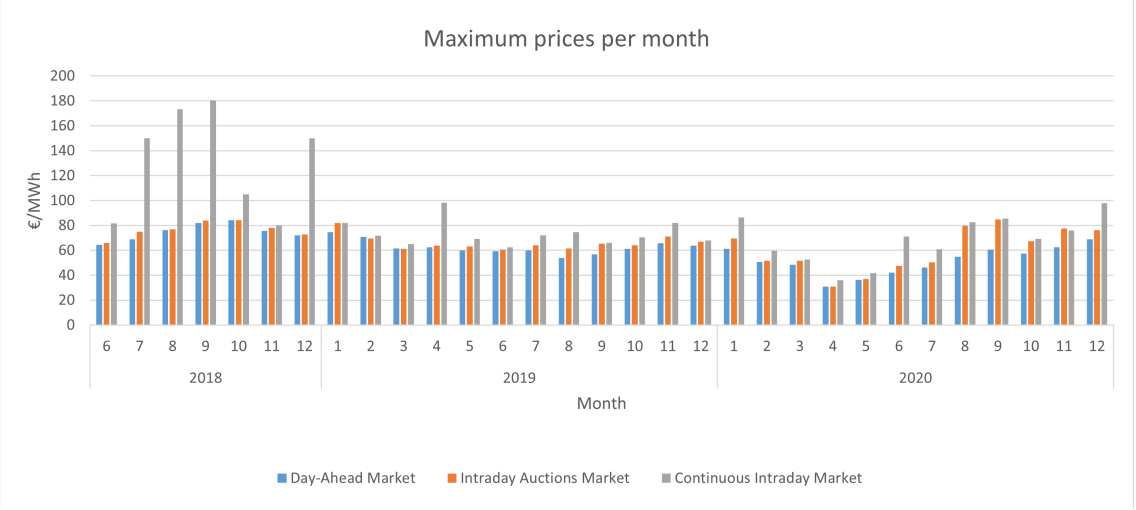

Figure 3.25: Evolution of the maximum energy prices per month of all three markets for 2018, 2019 and 2020

After analysing both graphics, it can be concluded that the Continuous Intraday Market appears to be the most volatile. It records the biggest maximum prices and the lowest minimum prices, as it would be expected of the market that has its negotiation rounds closer to delivery time.

The maximum price is recorded for the Continuous Intraday Market at 180.3 €/MWh on hour 5 of the 18th of September 2018 in Spain, and the minimum price is recorded for the same market at -23.02 €/MWh on hour 4 of the 25th of October 2020 due to an unexpected increase in wind power generation in the Iberian Market.

Chapter 4

Analysis of the traded energy

4.1 Introduction

In this chapter, the results for all three markets regarding volumes of traded energy will be analysed for each year from 2018 until 2020. Similarly to the last chapter, each year will be analysed separately and then they will be put together for a general analysis. Similarly to chapter 3, the month of August was chosen for the analysis of the average traded energy per day due to the fact that it is a month with data from all markets for all three years in study and that it contains an holiday in both Portugal and Spain, making it an interesting month to analyse.

The values used throughout this chapter are a sum of both Portuguese and Spanish energy values in order to obtain an Iberian Market value. These values were calculated using the Equation 3.2.

For this analysis it is necessary to assess the data provided publicly in the web page of the Iberian Market Operator, OMIE, which can be found in the following references [21, 22]. This data was processed with the help of Microsoft Excel and its Power Query feature.

4.2 Traded energy in 2018

The total volume of trade energy in 2018 was 234264 GWh for the Day-Ahead Market, 37357 GWh for the Intraday Auctions Market and 1030 GWh for the Continuous Intraday Market. Figure 4.1 represents these three volumes.

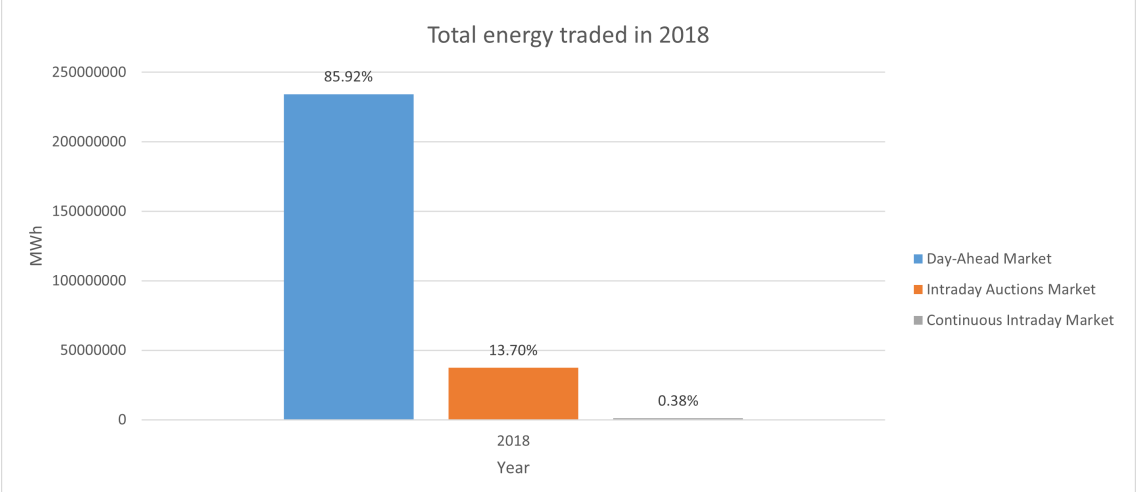

Figure 4.1: Total volume of traded energy in all three markets for the year of 2018

4.2.1 Traded energy per month

The graphic shown in Figure 4.2 represents the volume of traded energy per month in 2018.

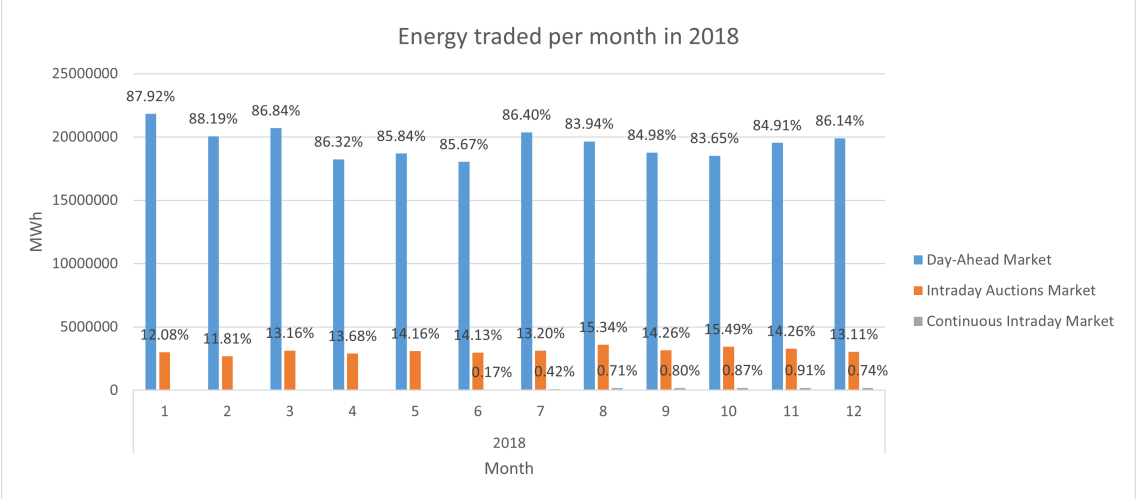

Figure 4.2: Volume of traded energy per month in all three markets for the year of 2018

It is possible to observe that the Day-Ahead Market had it's maximum value of traded energy in January with 21826 GWh. The Intraday Auctions Market recorded its maximum of 3592 GWh traded in August. While the Continuous Intraday Market had its maximum in November with 192 GWh of traded energy.

4.2.2 Traded energy per day

In order to observe the difference in energy demand between weekdays, weekends and holidays, Figure 4.3 shows the evolution of traded energy per day in August. Weekends are marked as grey zones, while the holiday, 15th of August, is marked as a green bar.

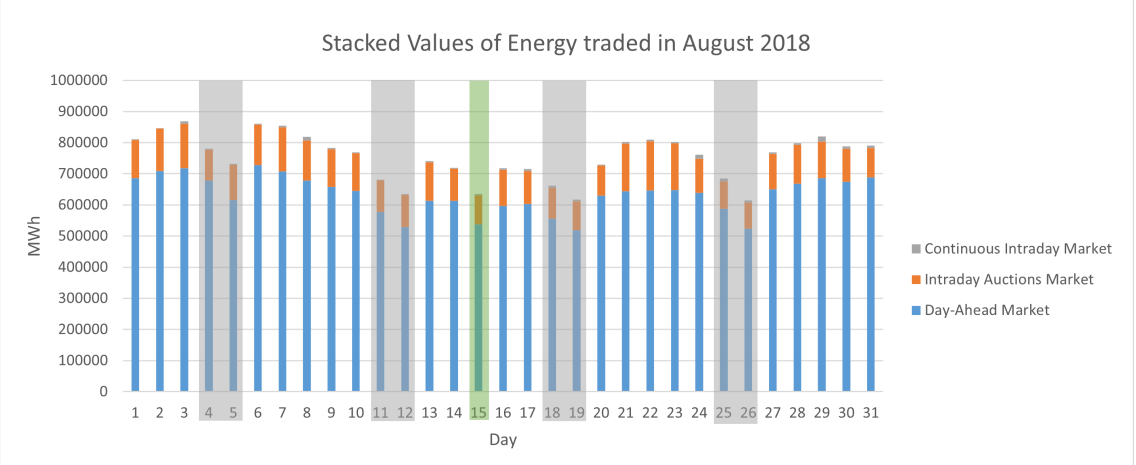

Figure 4.3: Evolution of the traded energy per day of all three markets for August 2018

The total volume of traded energy for the month of August was 19654 GWh for the Day-Ahead Market, 3592 GWh for the Intraday Auctions Market and 169 GWh for the Continuous Intraday Market.

In Figure 4.3 it is possible to observe that there is higher demand for energy during work days, and that weekends and holidays have the lowest values of traded energy.

4.2.3 Average traded energy per hour

Figures 4.4, 4.5 and 4.6 represent the evolution of the average traded energy per hour for the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market respectively.

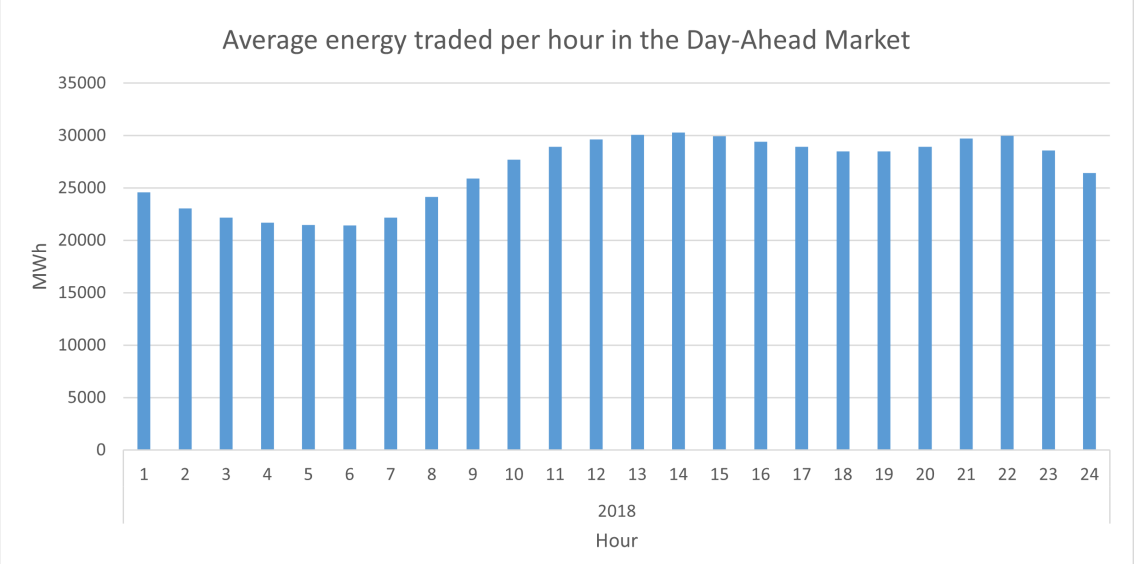

Figure 4.4: Evolution of the average traded energy per hour in the Day-Ahead Market for 2018

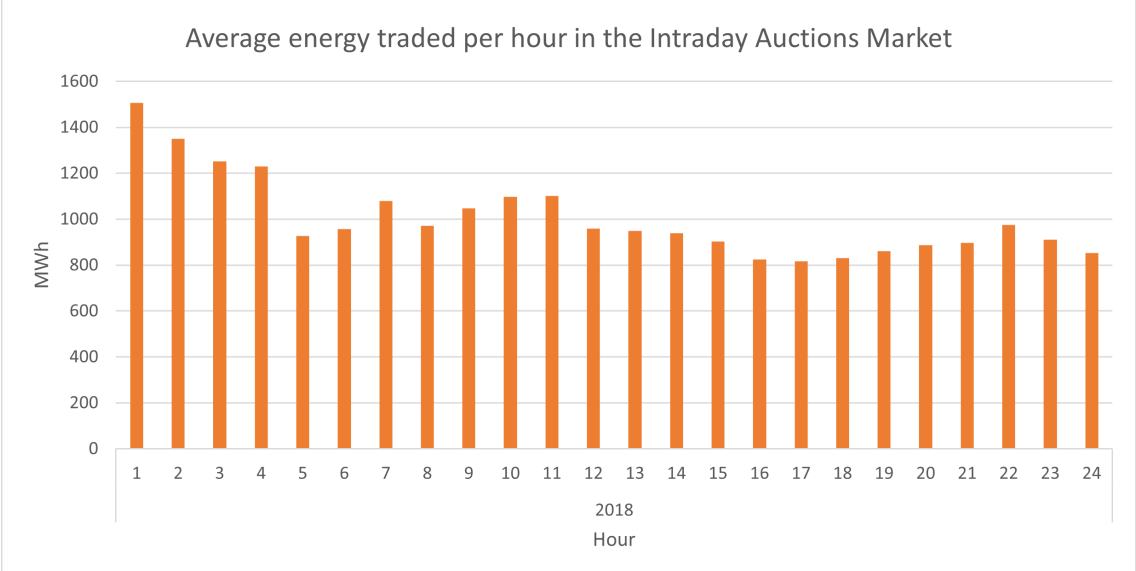

Figure 4.5: Evolution of the average traded energy per hour in the Intraday Auctions Market for 2018

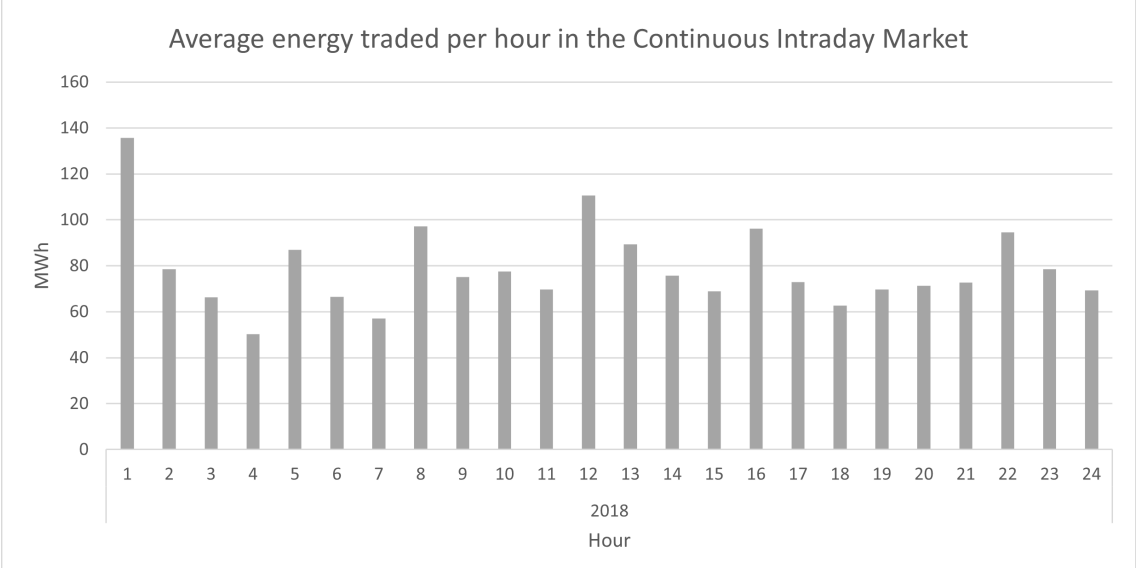

Figure 4.6: Evolution of the average traded energy per hour in the Continuous Intraday Market for 2018

In Figure 4.5 it is possible to observe that the Intraday Auctions Market follows the trend of the Day-Ahead Market with the exception of the first four hours of the day in which the Intraday Auctions Market has a larger share of liquidity. This might mean that agents are having a harder time forecasting these hours and resort to the Intraday Auctions Market to fix the imbalances in their programs.

The Continuous Intraday Market, that can be observed in Figure 4.6 records the peaks in volume of traded energy for the hours immediately before the Intraday Auction Market sessions

opening time, steadily decreasing for the following hours.

4.2.4 Correlation between traded energy and average prices

Figures 4.7, 4.8 and 4.9 illustrate de correlation between traded energy and average prices in each of the three markets.

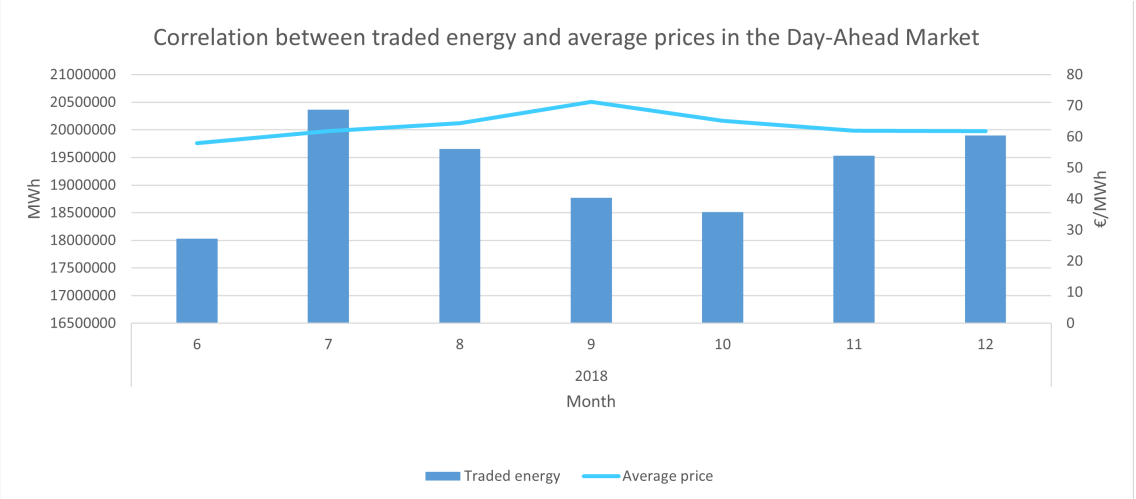

Figure 4.7: Correlation between traded energy and average price in 2018 for the Day-Ahead Market

In Figure 4.7 it is not possible to determine a relationship between the volume of traded energy and the average price, which might be due to the lack of renewable energy production, or because it still is a transition period because of the appearance of the Continuous Intraday Market, and agents are still not accustomed.

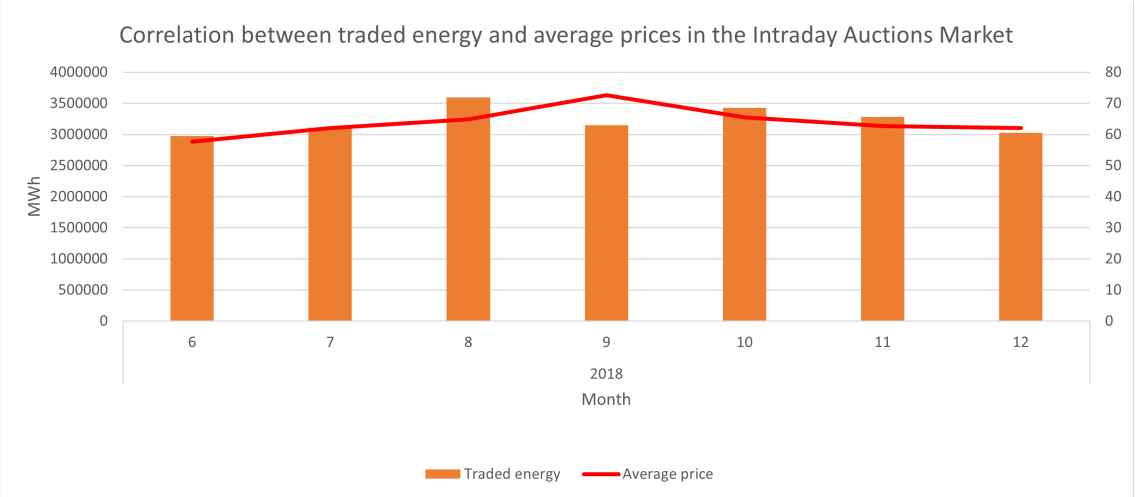

Figure 4.8: Correlation between traded energy and average price in 2018 for the Intraday Auctions Market

Figure 4.8, shows the closest correlation between traded energy and average price, which might mean that agents turned more often to the Intraday Auctions Market to adjust the programs resulted from the Day-Ahead Market.

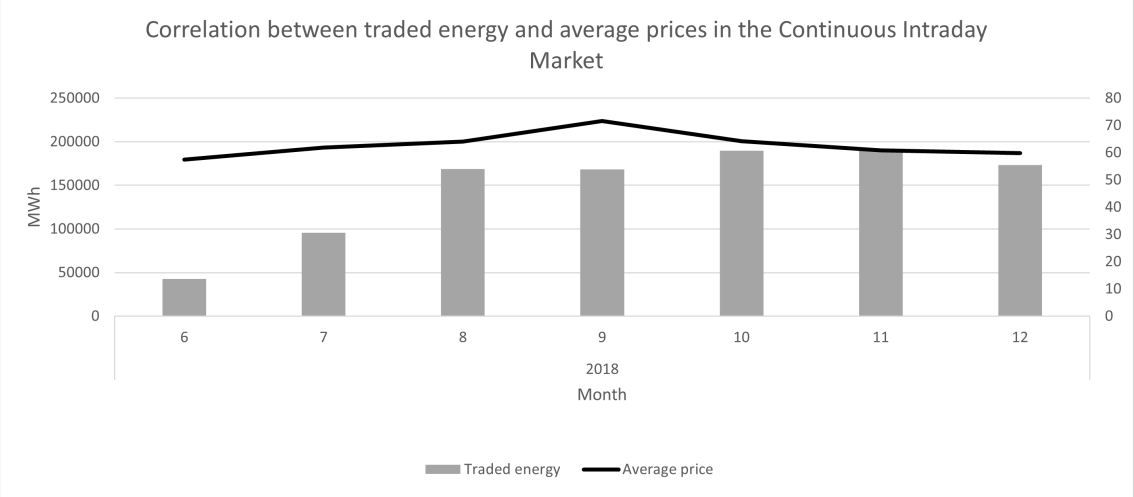

Figure 4.9: Correlation between traded energy and average price in 2018 for the Continuous Intraday Market

Analysing Figure 4.9 it is possible to verify that besides the first two months of the Continuous Intraday Market, the relationship between the amount of traded energy and the average price follow the same trend. June and July have specially low values of traded energy due to the fact that they are the first ever two months since the beginning of the Continuous Intraday Market.

4.2.5 Average traded energy per session or round

Figure 4.10 and Table 4.1 represent the average volume of traded energy per session in 2018.

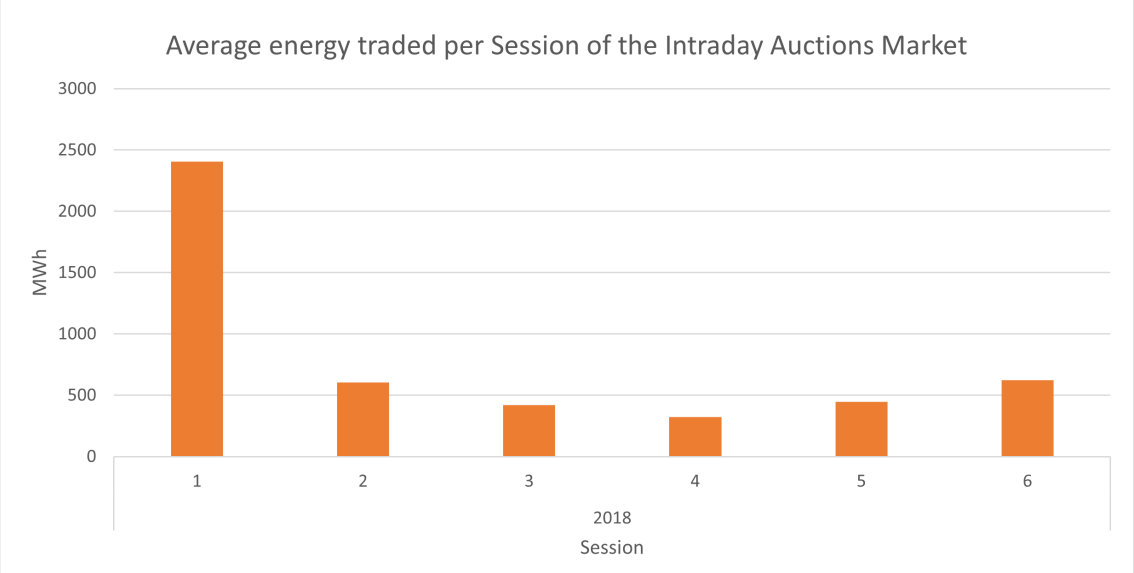

Figure 4.10: Evolution of the average traded energy per session of the Intraday Auctions Market for 2018

Table 4.1: Average volume of traded energy per session of the Intraday Auctions Market for 2018, values in MWh

Session	Intraday Auctions Market
1	2405
2	605
3	420
4	322
5	447
6	622

Through Table 4.1 it is clear that session one is the one in which more energy is traded. The average traded energy in each hour per session of the Intraday Auctions Market is represented in Figure 4.11. Here we can confirm that most energy transactions, made through the Intraday Auctions Market, for the whole day are done in session 1.

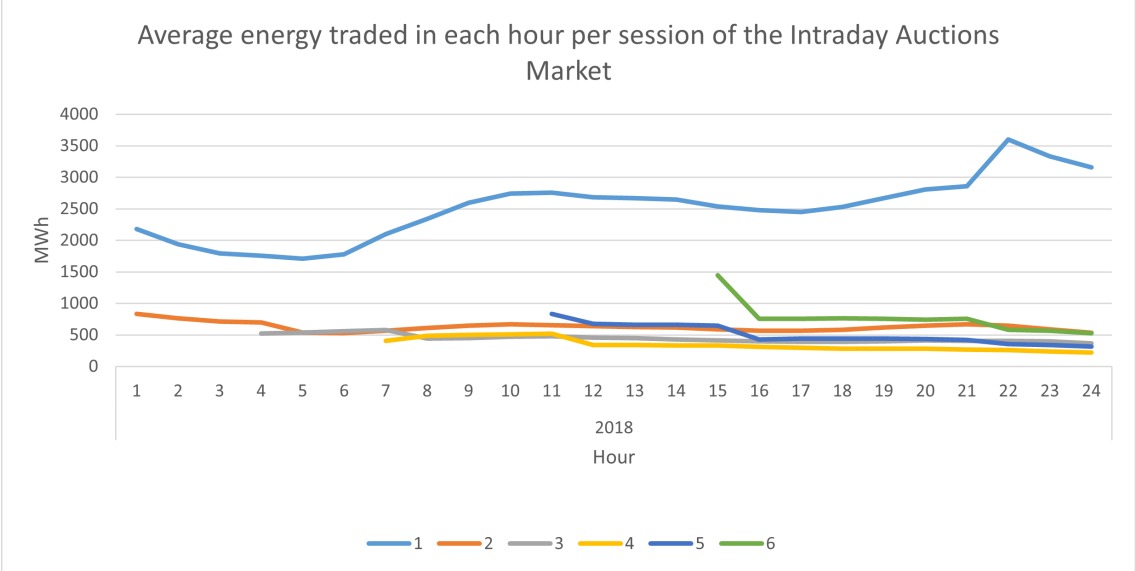

Figure 4.11: Evolution of the average traded energy in each hour per session of the Intraday Auctions Market for 2018

The average volume of traded energy per round of the Continuous Intraday Market can be found in Figure 4.12, where we can confirm that the round with the highest value of traded energy was round 21 with a value of 135 MWh.

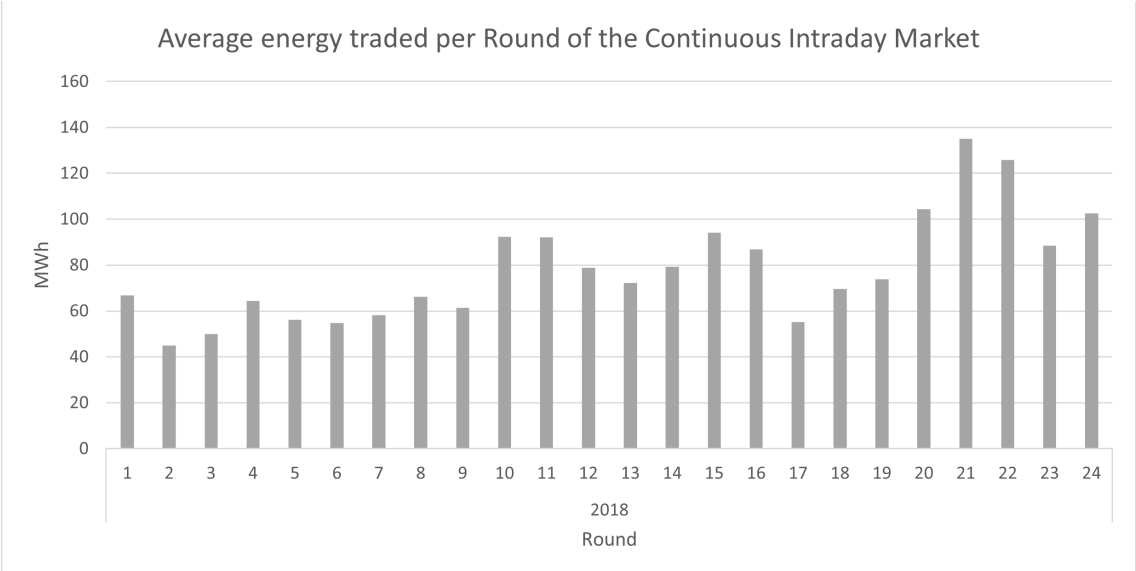

Figure 4.12: Evolution of the average traded energy per round of the Continuous Intraday Market for 2018

Figure 4.13 shows the average traded energy per hour of each round of the Continuous Intraday Market for 2018.

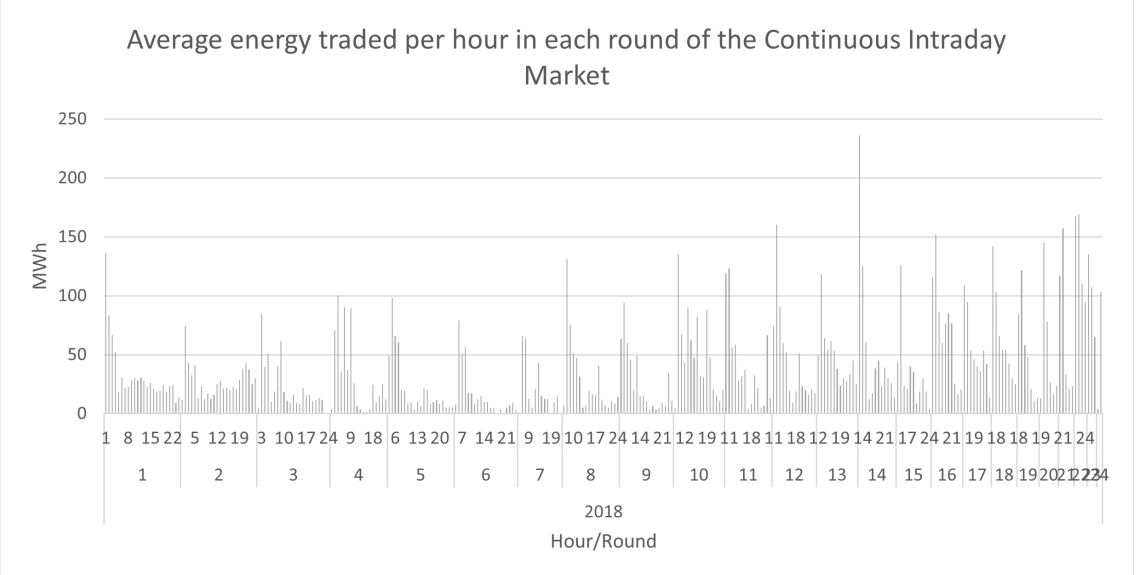

Figure 4.13: Evolution of the average traded energy per hour in each round of the Continuous Intraday Market for 2018

In this graphic we can verify that each round has its peak of traded energy for the first hour traded in that same round, in other words, for the hour that is closer to delivery time during the opening of the round contract.

4.3 Traded energy in 2019

The total volume of traded energy in 2019 was 226431 GWh for the Day-Ahead Market, 34088 GWh for the Intraday Auctions Market and 2179 GWh for the Continuous Intraday Market. Figure 4.14 represents these three volumes.

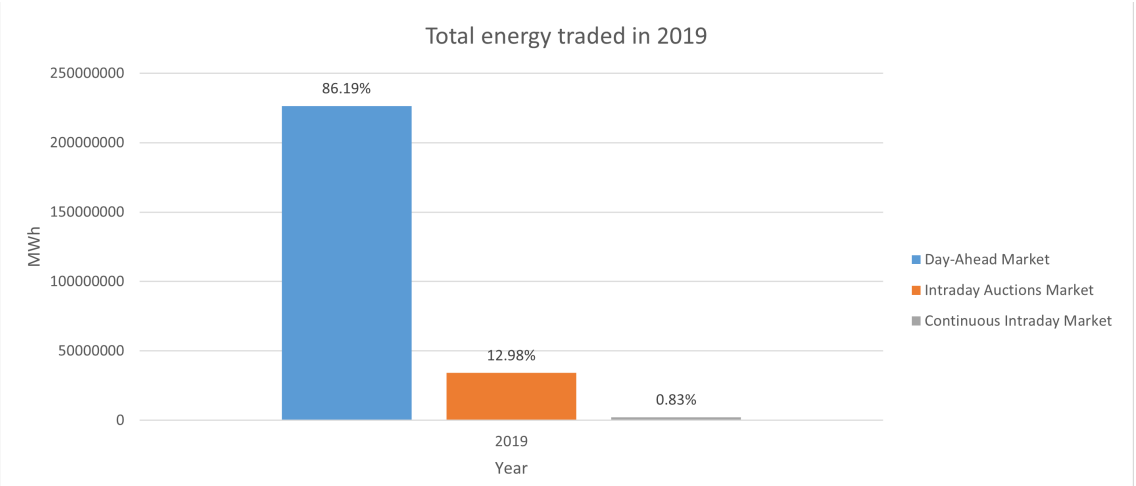

Figure 4.14: Total volume of traded energy in all three markets for the year of 2019

4.3.1 Traded energy per month

The graphic shown in Figure 4.15 represents the volume of traded energy per month in 2019.

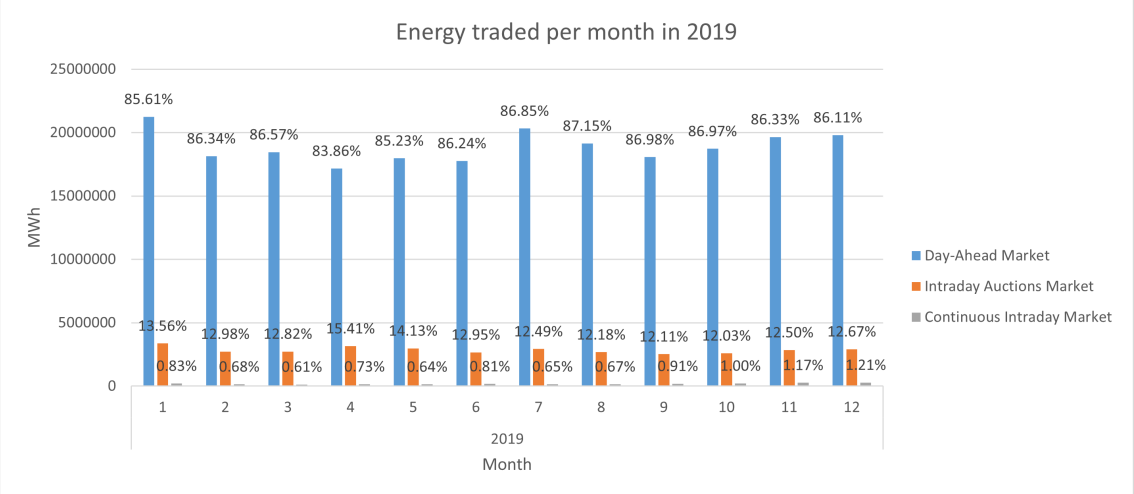

Figure 4.15: Volume of traded energy per month in all three markets for the year of 2019

For 2019, the maximum volume of traded energy for the Day-Ahead Market was recorded in January with 21247 GWh traded. The Intraday Auctions Market recorded its maximum value also in January with a total of 3366 GWh traded. And finally the Continuous Intraday Market had its maximum in December with a value of 279 GWh.

4.3.2 Traded energy per day

Just like in 2018, in order to observe the difference in energy demand between weekdays, weekends and holidays, Figure 4.16 shows the evolution of traded energy per day in August. Weekends are marked as grey zones, while the holiday, 15th of August, is marked as a green bar.

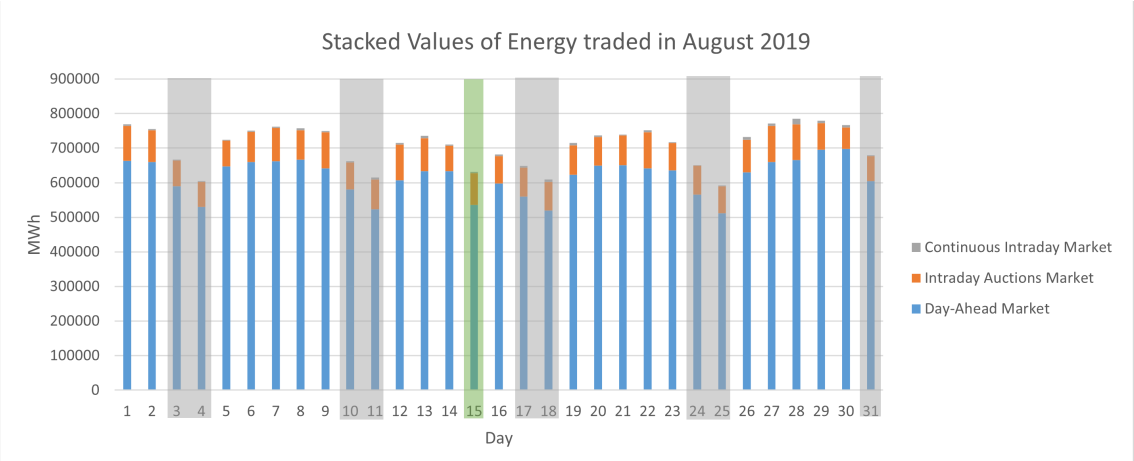

Figure 4.16: Evolution of the traded energy per day of all three markets for August 2019

The total volume of traded energy for the month of August was 19141 GWh for the Day-Ahead Market, 2674 GWh for the Intraday Auctions Market and 148 GWh for the Continuous Intraday Market.

4.3.3 Average traded energy per hour

Figures 4.17, 4.18 and 4.19 represent the evolution of the average traded energy per hour for the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market, respectively, in 2019.

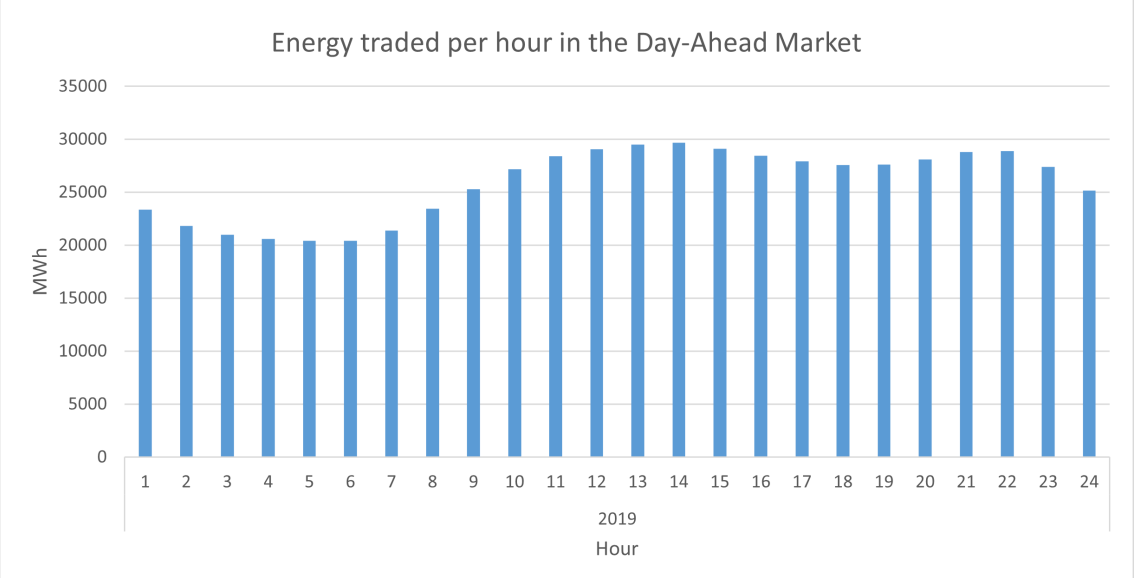

Figure 4.17: Evolution of the average traded energy per hour in the Day-Ahead Market for 2019

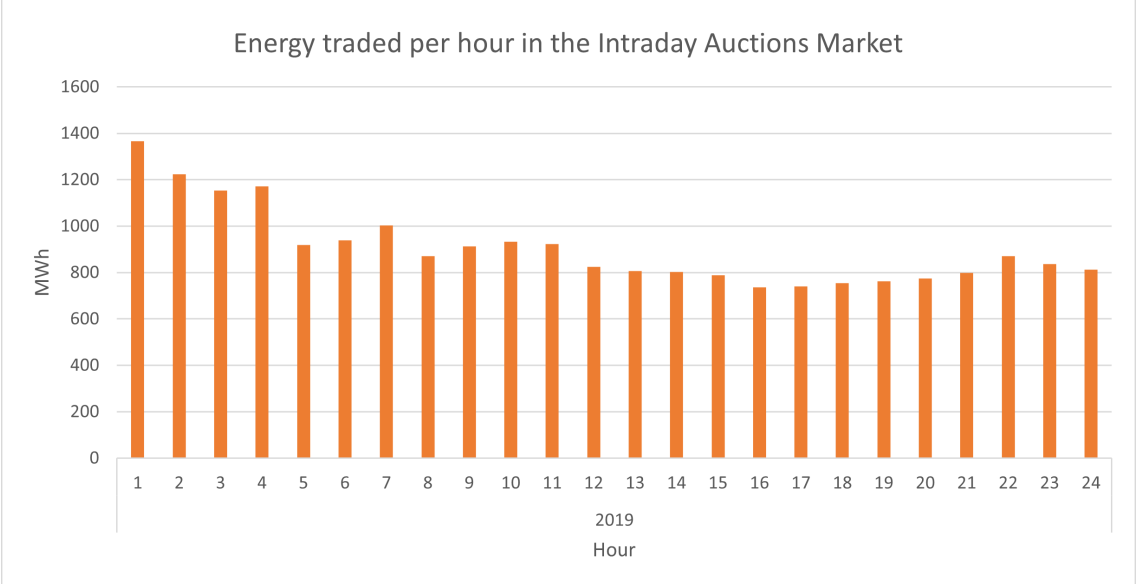

Figure 4.18: Evolution of the average traded energy per hour in the Intraday Auctions Market for 2019

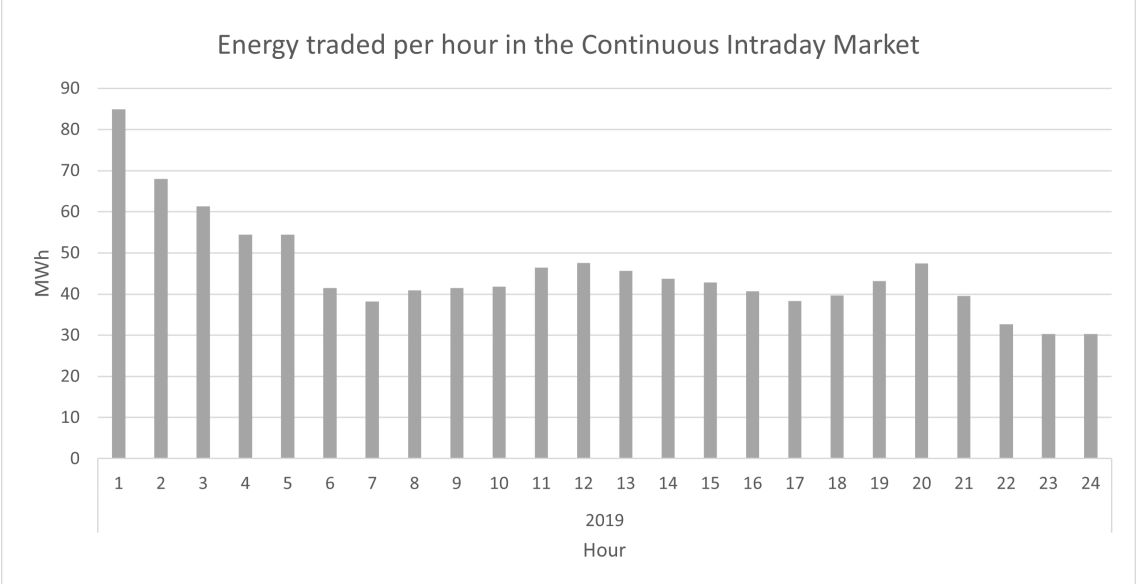

Figure 4.19: Evolution of the average traded energy per hour in the Continuous Intraday Market for 2019

The Intraday Auctions Market follows the same trend as in the previous year. On the other hand, the Continuous Intraday Market, shown in Figure 4.19, instead of behaving like in 2018, starts following the same trend of the Intraday Auctions Market.

4.3.4 Correlation between traded energy and average prices

Figures 4.20, 4.21 and 4.22 illustrate de correlation between traded energy and average prices in each of the three markets.

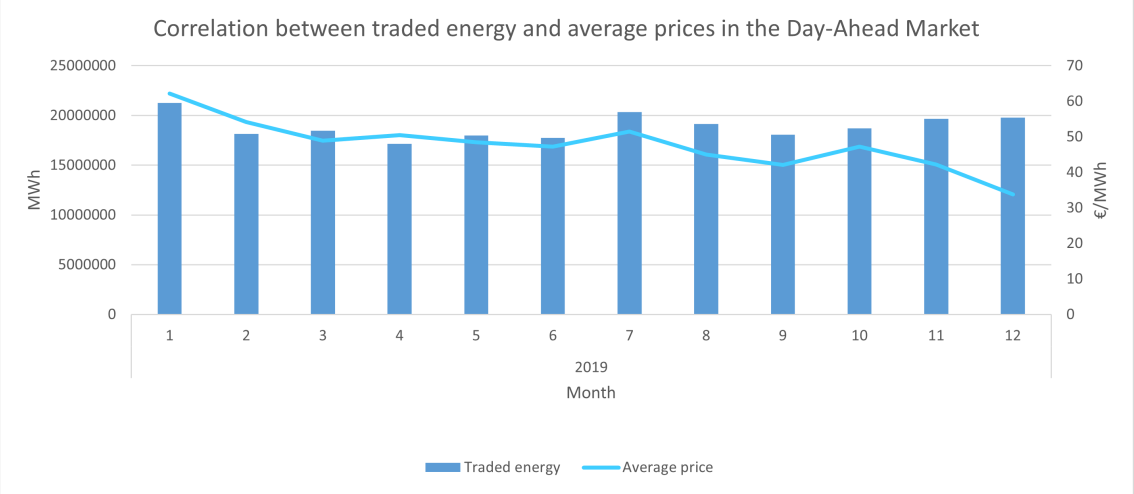

Figure 4.20: Correlation between traded energy and average price in 2019 for the Day-Ahead Market

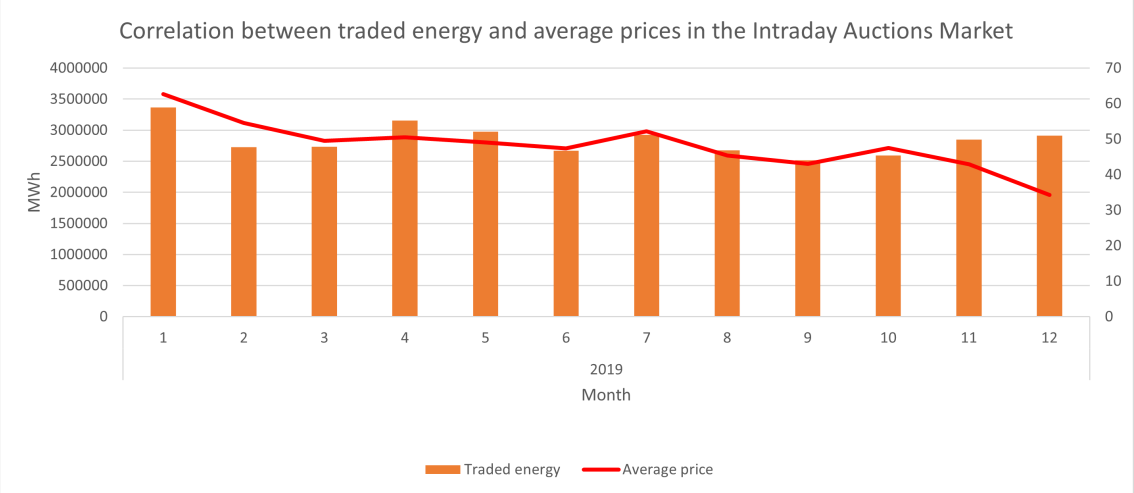

Figure 4.21: Correlation between traded energy and average price in 2019 for the Intraday Auctions Market

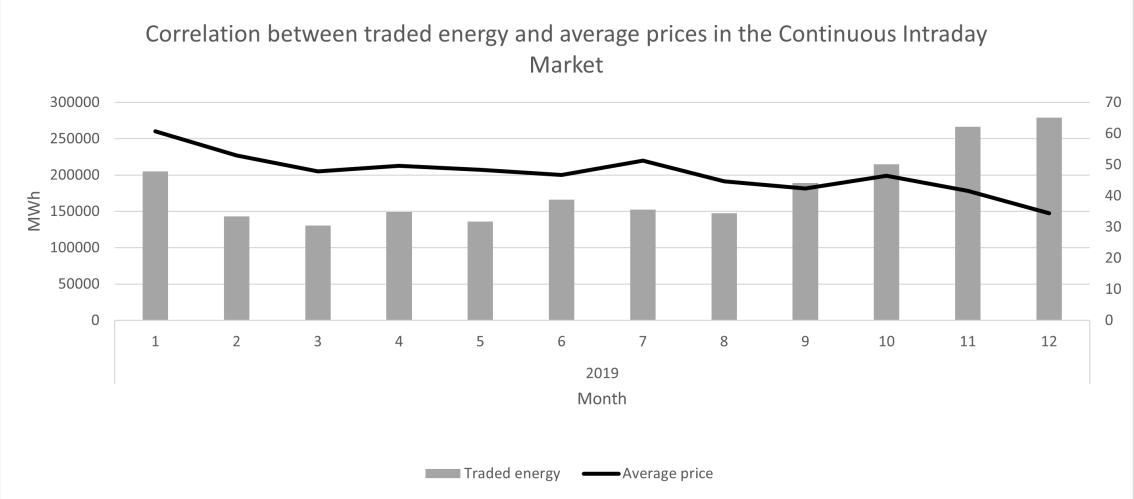

Figure 4.22: Correlation between traded energy and average price in 2019 for the Continuous Intraday Market

Overall, the average monthly price of all three markets in 2019 follows the trend of the volume of traded energy with the exception of November and December. This was due to an increase of generation due to renewable sources, in those two months, that broke records in the Iberian Peninsula. For the first time, during more than five straight days, the renewable sources generated enough energy to supply Portugal and Spain.

4.3.5 Average traded energy per session or round

Figure 4.23 and Table 4.2 represent the average volume of traded energy per session in 2019.

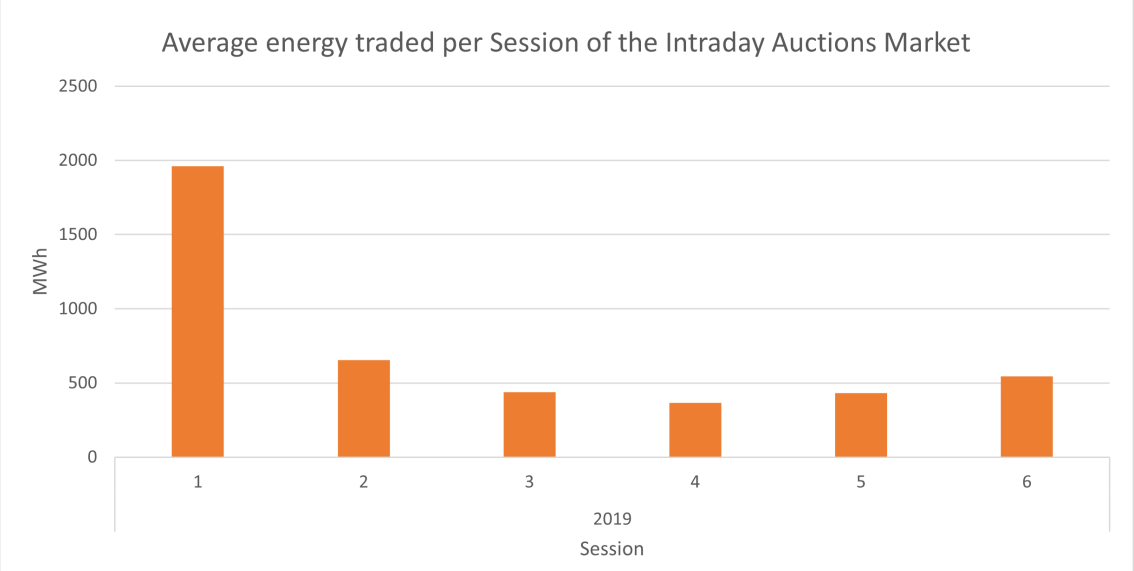

Figure 4.23: Evolution of the average traded energy per session of the Intraday Auctions Market for 2019

Table 4.2: Average volume of traded energy per session of the Intraday Auctions Market for 2019, values in MWh

Session	Intraday Auctions Market
1	1962
2	655
3	439
4	365
5	431
6	545

Through Table 4.2 it is clear to see that, once again, session one is the one in which more energy is traded. The average traded energy in each hour per session of the Intraday Auctions Market is represented in Figure 4.24 regarding which the same conclusions taken from 2018 still apply.

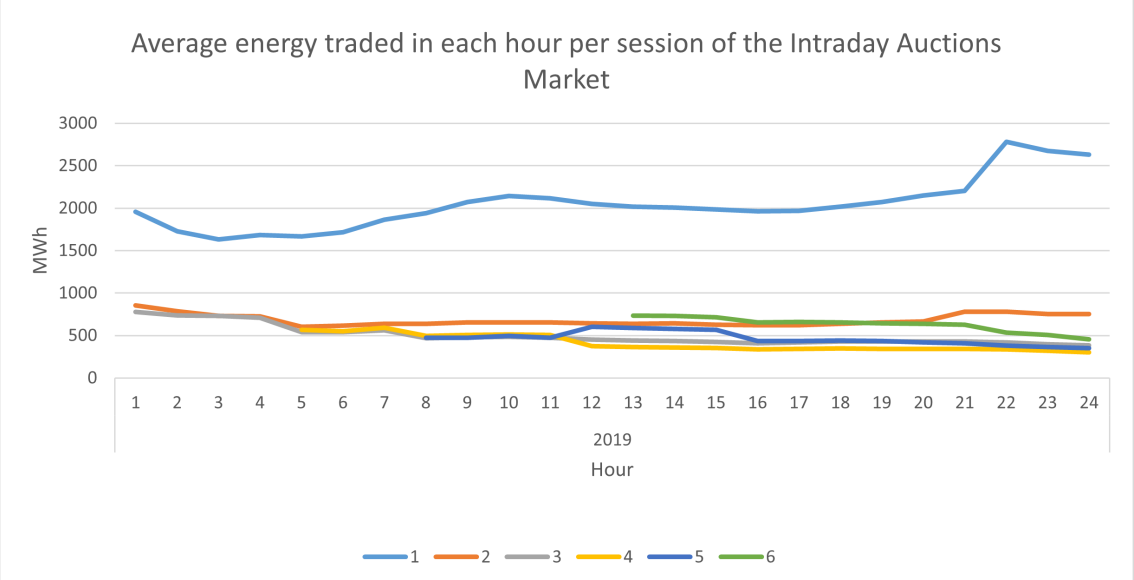

Figure 4.24: Evolution of the average traded energy in each hour per session of the Intraday Auctions Market for 2019

The average volume of traded energy per round of the Continuous Intraday Market can be found in Figure 4.25, where we can confirm that the round with the highest value of average traded energy was round 20 with a value of 69 MWh.

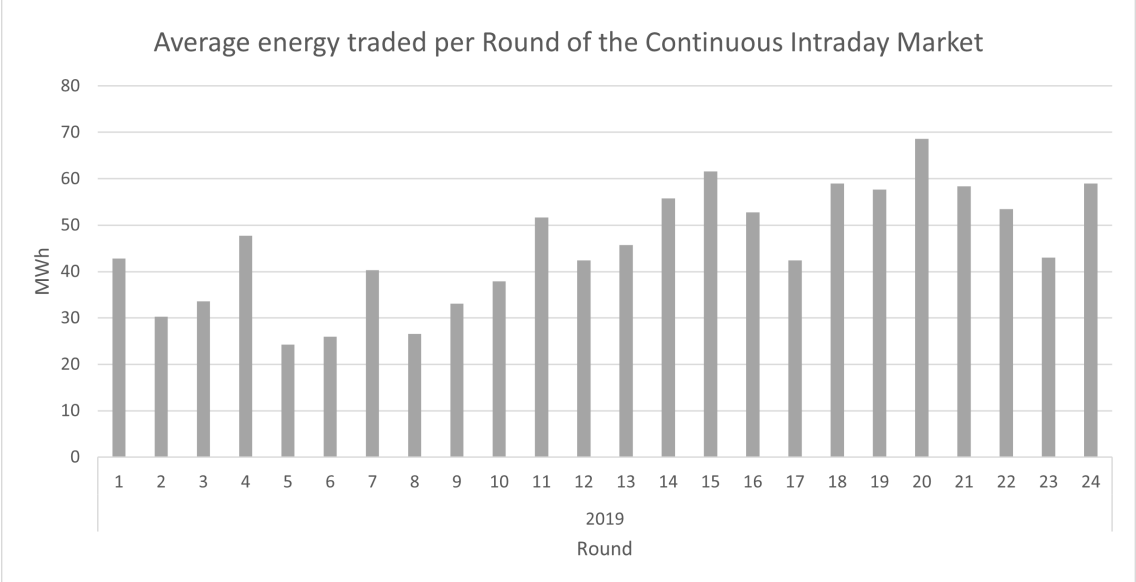

Figure 4.25: Evolution of the average traded energy per round of the Continuous Intraday Market for 2019

It is also interesting to notice that the rounds where there is more liquidity correspond to the rounds where the price was the lowest, corresponding to the hour of delivery immediately before the opening time of each of the Intraday Auctions Market sessions.

Figure 4.26 shows the average traded energy per hour of each round of the Continuous Intraday Market for 2019.

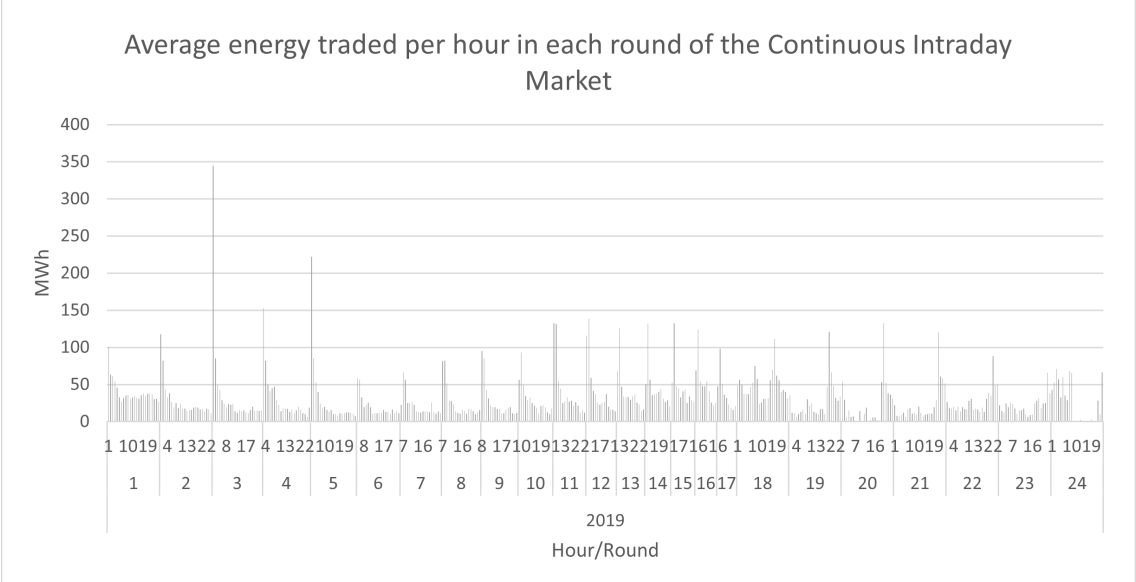

Figure 4.26: Evolution of the average traded energy per hour in each round of the Continuous Intraday Market for 2019

Just like in 2018, the hours that have the largest traded energy per hour are the ones closer to delivery time for that specific round contract.

4.4 Traded energy in 2020

The total volume of traded energy in 2020 was 219063 GWh for the Day-Ahead Market, 31081 GWh for the Intraday Auctions Market and 3534 GWh for the Continuous Intraday Market. Figure 4.27 represents those three volumes.

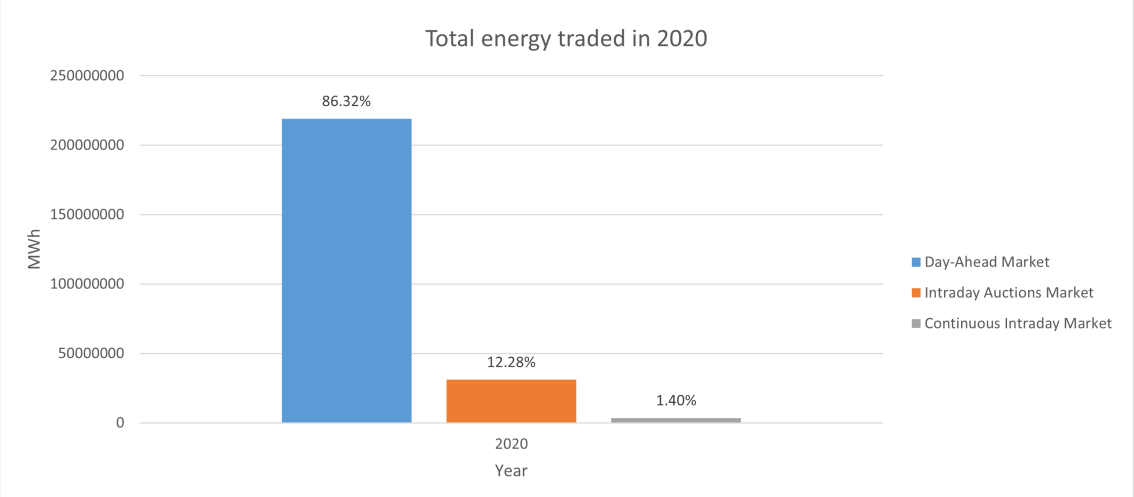

Figure 4.27: Total volume of traded energy in all three markets for the year of 2020

4.4.1 Traded energy per month

The graphic shown in Figure 4.28 represents the volume of traded energy per month in 2020.

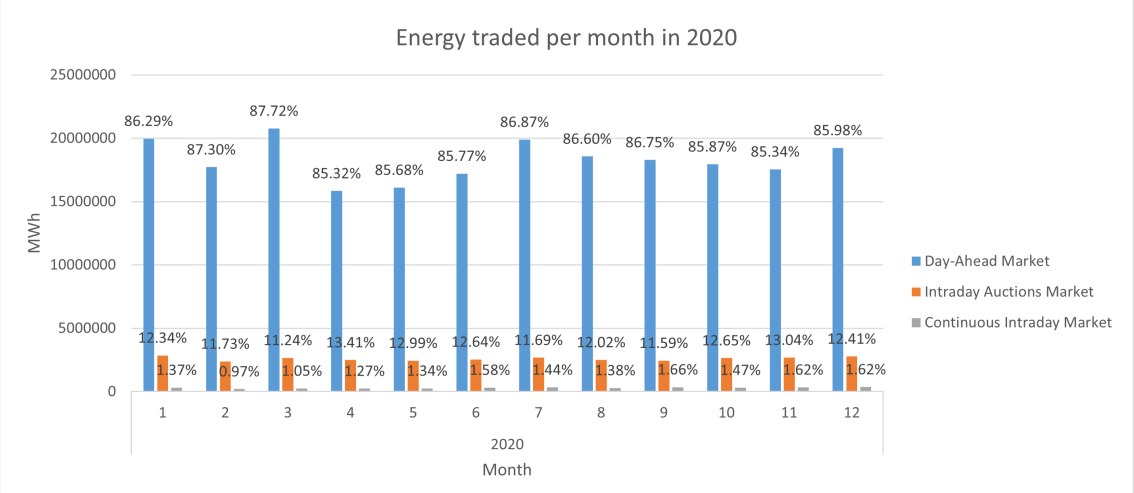

Figure 4.28: Volume of traded energy per month in all three markets for the year of 2020

The maximum volume of traded energy per month for the Day-Ahead Market in 2020 was in March with 20767 GWh traded. The Intraday Auctions Market recorded its maximum value of traded energy in January with a total of 2855 GWh traded. While the Continuous Intraday Market had it's maximum value in December with 349 GWh of traded energy.

4.4.2 Traded energy per day

Similarly to 2018 and 2019, in order to observe the difference in energy demand between weekdays, weekends and holidays, Figure 4.29 shows the evolution of traded energy per day in August. Weekends are marked as grey zones, while the holiday, 15th of August, is marked as a green bar.

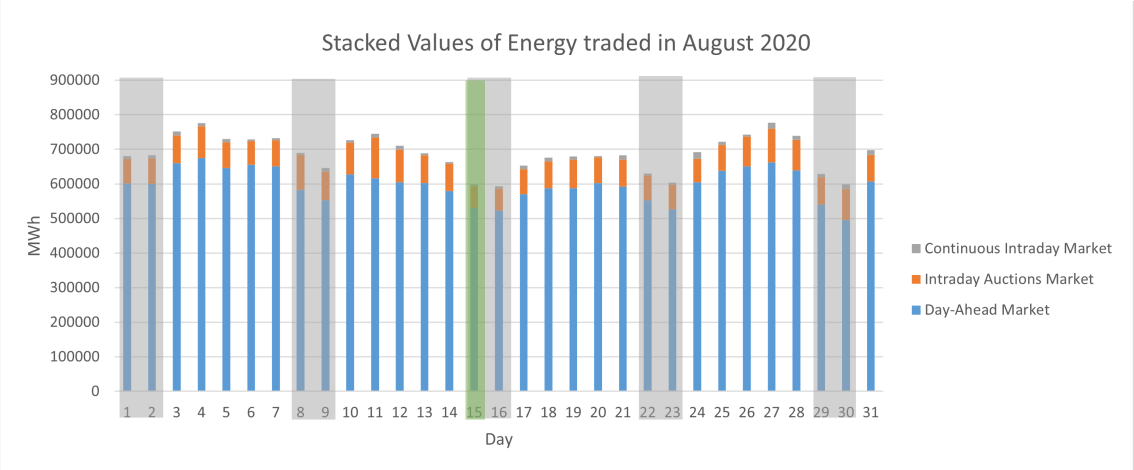

Figure 4.29: Evolution of the traded energy per day of all three markets for August 2020

The total volume of traded energy for the month of August was 18561 GWh for the Day-Ahead Market, 2498 GWh for the Intraday Auctions Market and 287 GWh for the Continuous Intraday Market.

4.4.3 Average traded energy per hour

Figures 4.30, 4.31 and 4.32 represent the evolution of the average traded energy per hour for the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market, respectively, in 2020.

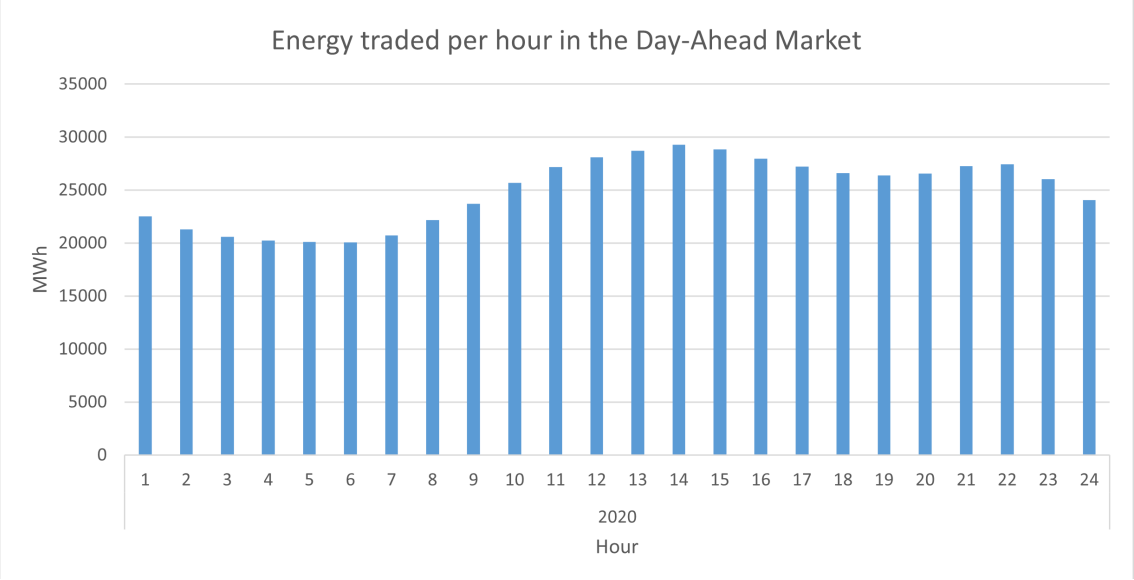

Figure 4.30: Evolution of the average traded energy per hour in the Day-Ahead Market for 2020

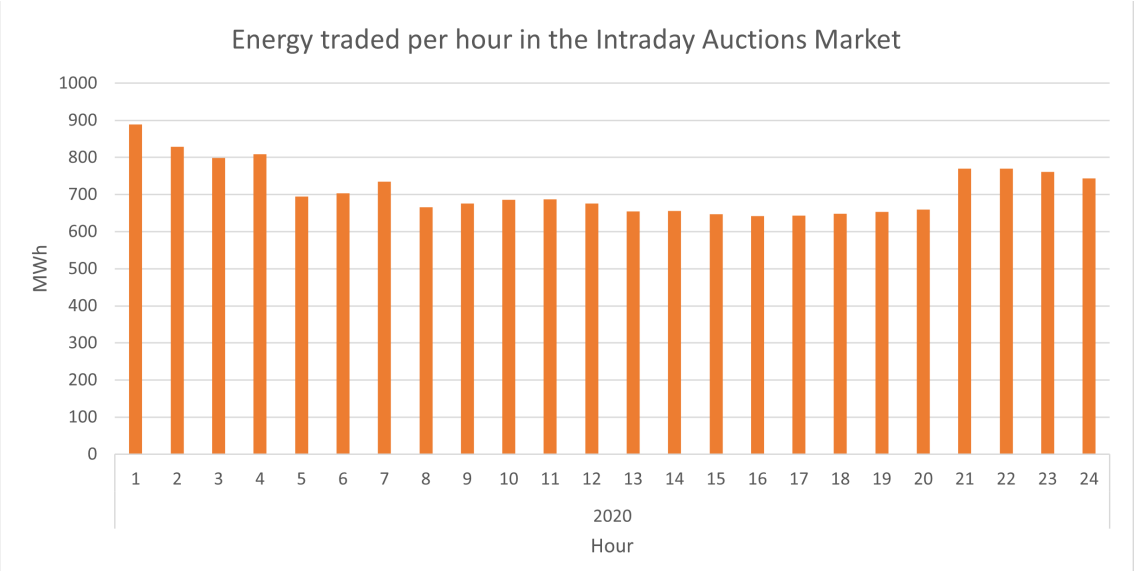

Figure 4.31: Evolution of the average traded energy per hour in the Intraday Auctions Market for 2020

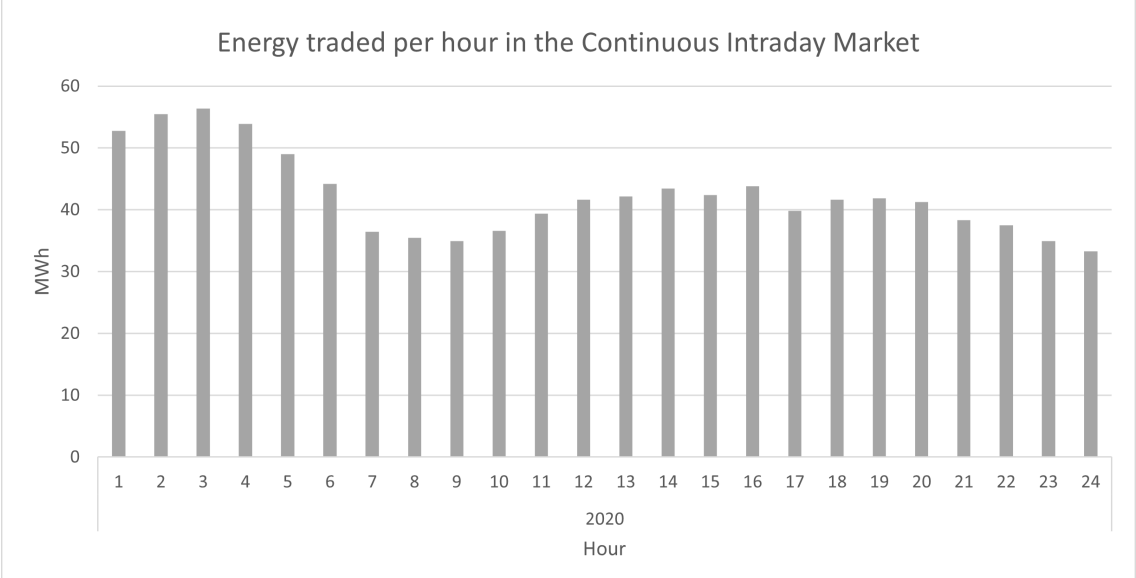

Figure 4.32: Evolution of the average traded energy per hour in the Continuous Intraday Market for 2020

This time the Intraday Auctions Market, represented in Figure 4.31 shows a more balanced amount of traded energy throughout the day with slight increases on the first and last four hours. The Continuous Intraday Market once again changed its trend to follow the Day-Ahead Market curve with the exception of the first hours of the day, where it looks that the opposite behavior is occurring. In other words, from hour 1 to 6 it shows an increase of traded energy, while the Day-Ahead Market shows a decrease.

4.4.4 Correlation between traded energy and average prices

Figures 4.33, 4.34 and 4.35 illustrate de correlation between traded energy and average prices in each of the three markets.

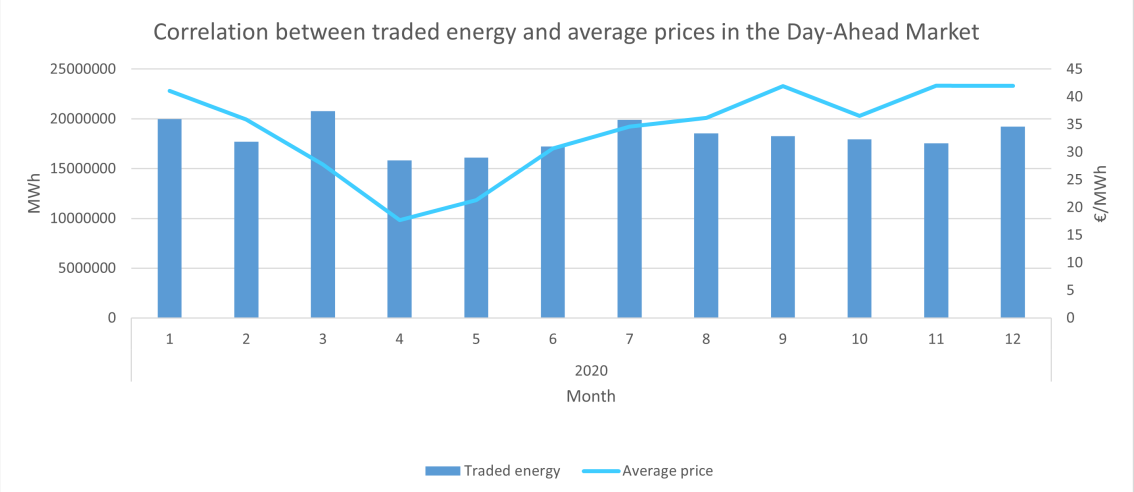

Figure 4.33: Correlation between traded energy and average price in 2020 for the Day-Ahead Market

With the exception of the first three months of lockdown, March, April and May, the Day-Ahead Market prices follow the trend of the volume of traded energy for each month.

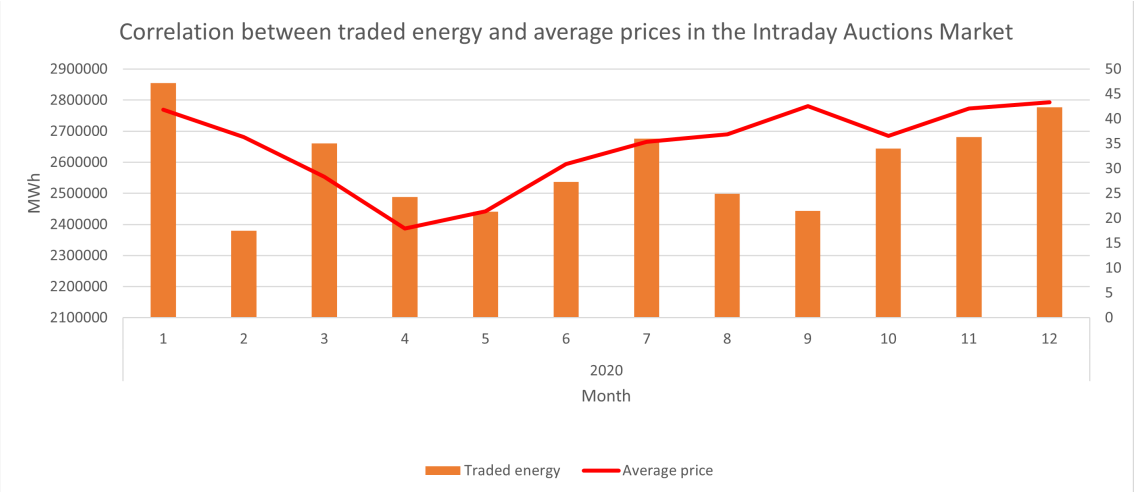

Figure 4.34: Correlation between traded energy and average price in 2020 for the Intraday Auctions Market

In the Intraday Auctions Market, the months of February, August and September present abnormal decreases in the amount of traded energy. Besides those months, just like the Day-Ahead Market, the average prices follow the trend of the volume of traded energy.

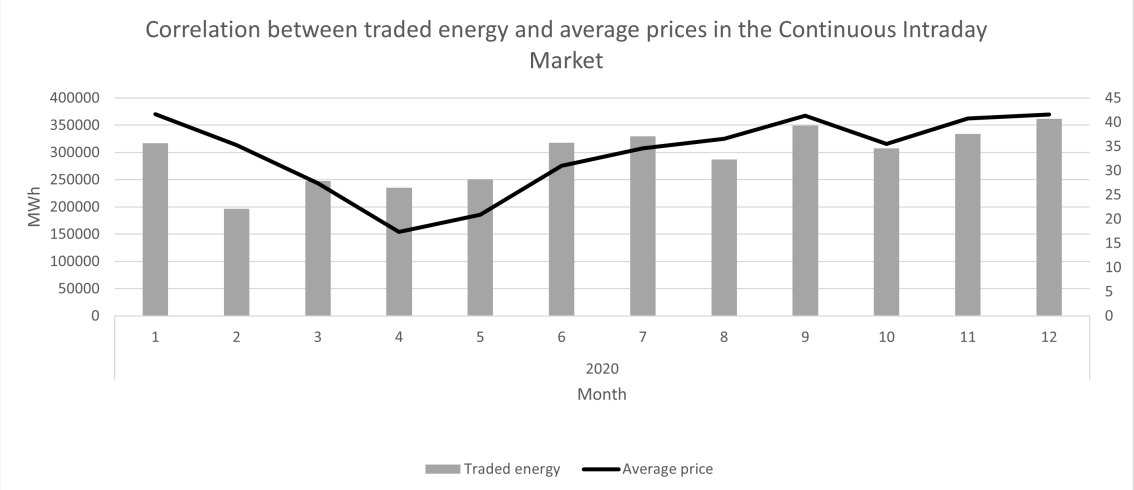

Figure 4.35: Correlation between traded energy and average price in 2020 for the Continuous Intraday Market

Finally in Figure 4.35 the Continuous Intraday Market, with the exception of February and the first months of lockdown, is the market where the correlation between the traded energy and the average prices is the strongest. February represented the month of the 2020 with the lowest amount of renewable generation, with more than 120 hours in which the renewable generation was not enough to fulfill the consumption demand.

4.4.5 Average traded energy per session or round

Figure 4.36 and Table 4.3 represent the average volume of traded energy per session in 2020.

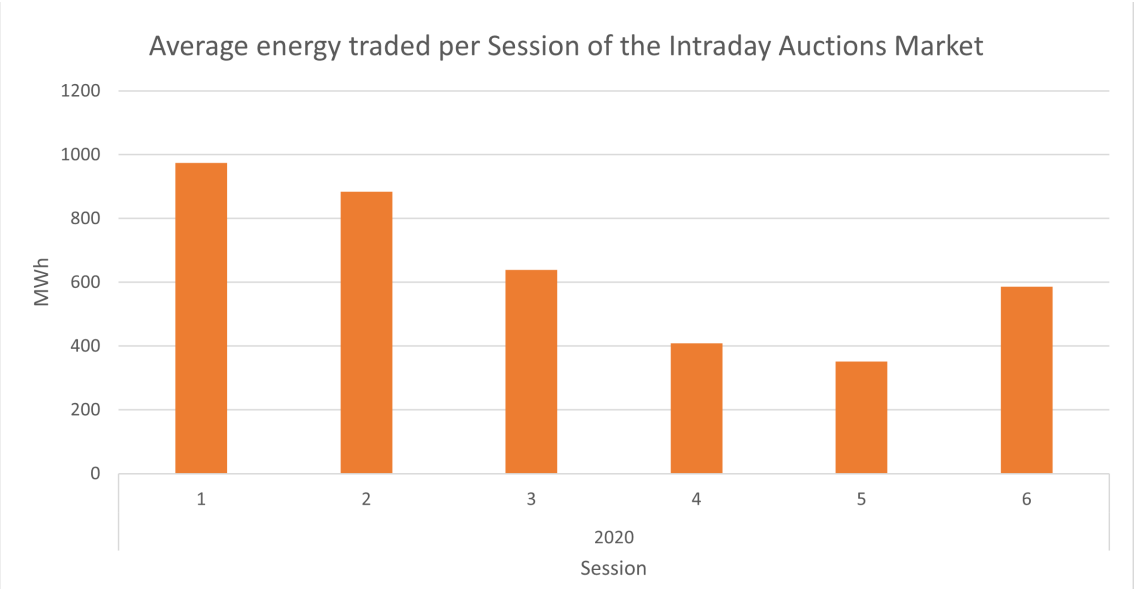

Figure 4.36: Evolution of the average traded energy per session of the Intraday Auctions Market for 2020

Table 4.3: Average volume of traded energy per session of the Intraday Auctions Market for 2020, values in MWh

Session	Intraday Auctions Market
1	974
2	885
3	639
4	408
5	351
6	586

Through Table 4.3 we can verify that session 1 still has the highest volume of traded energy. The average traded energy in each hour per session of the Intraday Auctions Market is represented in Figure 4.37 where we can see the difference between previous years on the last four hours of the day, that shifted from being traded more in session 1 to session 2.

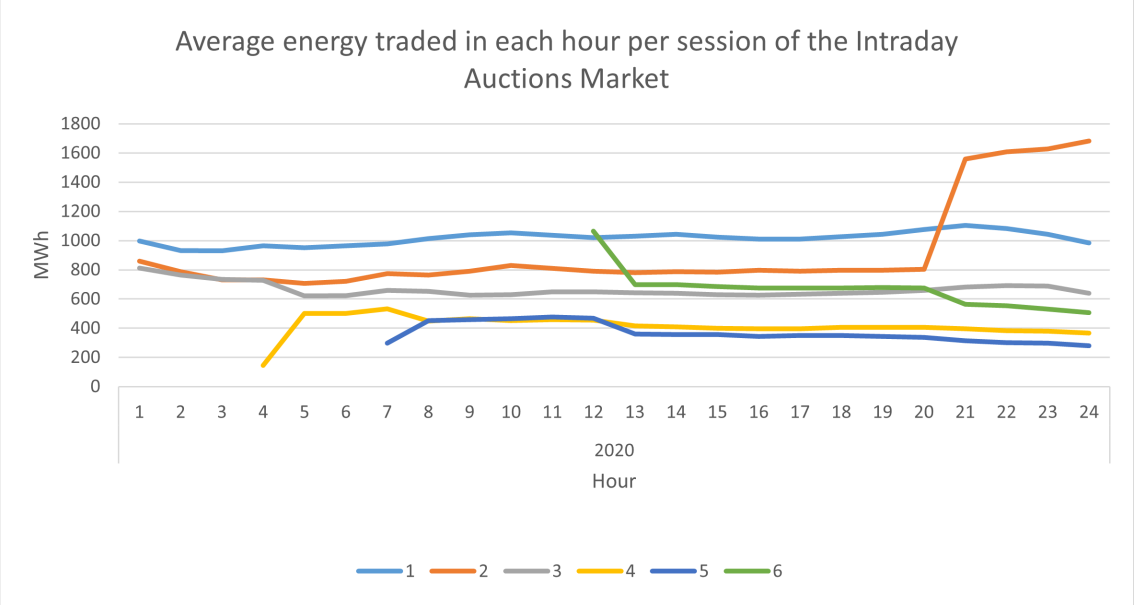

Figure 4.37: Evolution of the average traded energy in each hour per session of the Intraday Auctions Market for 2020

The average volume of traded energy per round of the Continuous Intraday Market can be found in Figure 4.38, where we can confirm that the round with the highest value of average traded energy was once again round 20 with a value of 74 MWh.

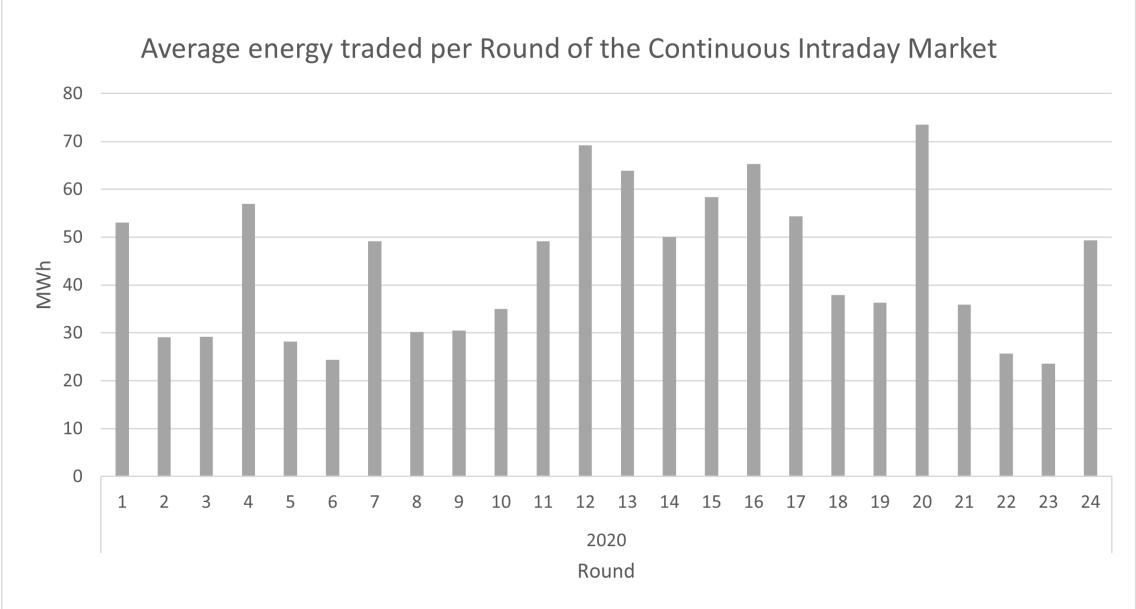

Figure 4.38: Evolution of the average traded energy per round of the Continuous Intraday Market for 2020

Figure 4.39 shows the average traded energy per hour of each round of the Continuous Intraday Market for 2020. This trend can also be observed in the previous years.

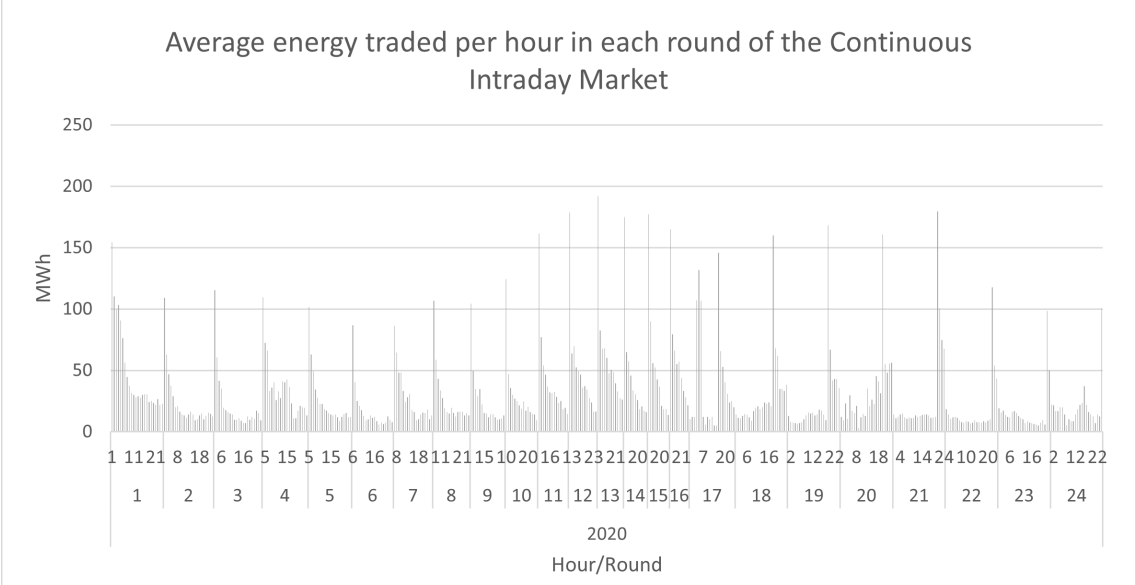

Figure 4.39: Evolution of the average traded energy per hour in each round of the Continuous Intraday Market for 2020

4.5 General analysis of all three years

Figure 4.40 shows the evolution of the total volume of traded energy in each market throughout the years. As would be expected, the Day-Ahead market is responsible for around 86% of the traded energy every hour. The Intraday Auctions Market is responsible for around 13%. And finally, the Continuous Intraday Market is responsible for the remaining 1%.

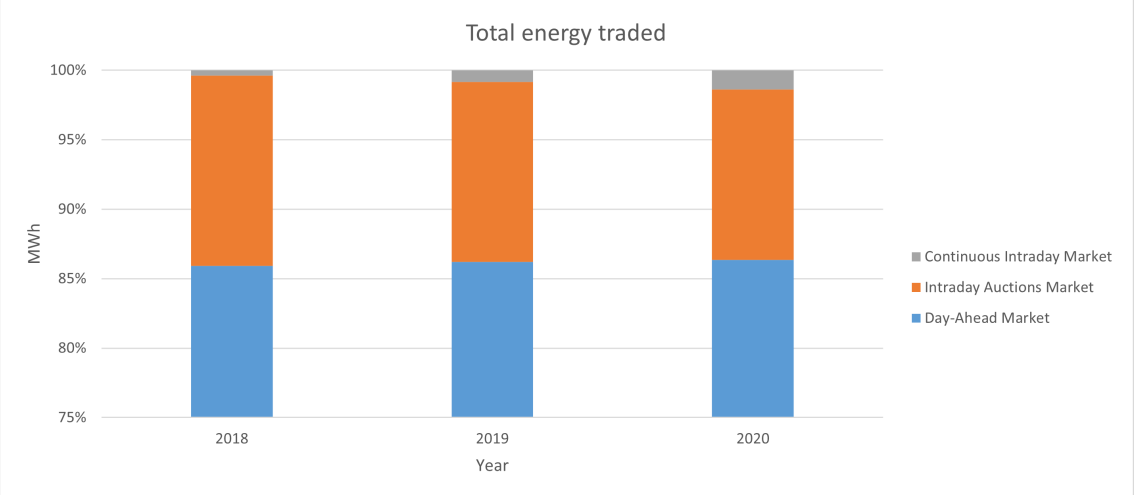

Figure 4.40: Percentile evolution of the total volume of traded energy in each market for 2018, 2019 and 2020

Table 4.4 represents the values used for Figure 4.40.

Table 4.4: Average traded energy in each market for the years of 2018, 2019 and 2019, values in GWh

	Day-Ahead Market	Intraday Auctions Market	Continuous Intraday Market
2018	234264	37357	1030
2019	226431	34088	2179
2020	219063	31081	3534

It is possible to notice a slight increase in the traded energy through the Continuous Intraday Market over the years while the other two markets recorded a decrease. Meaning that agents have been using the Continuous Intraday Market more for their transactions.

4.5.1 Monthly analysis

Figure 4.41 demonstrates the evolution of total traded energy per month throughout the years for the Day-Ahead and both Intraday markets.

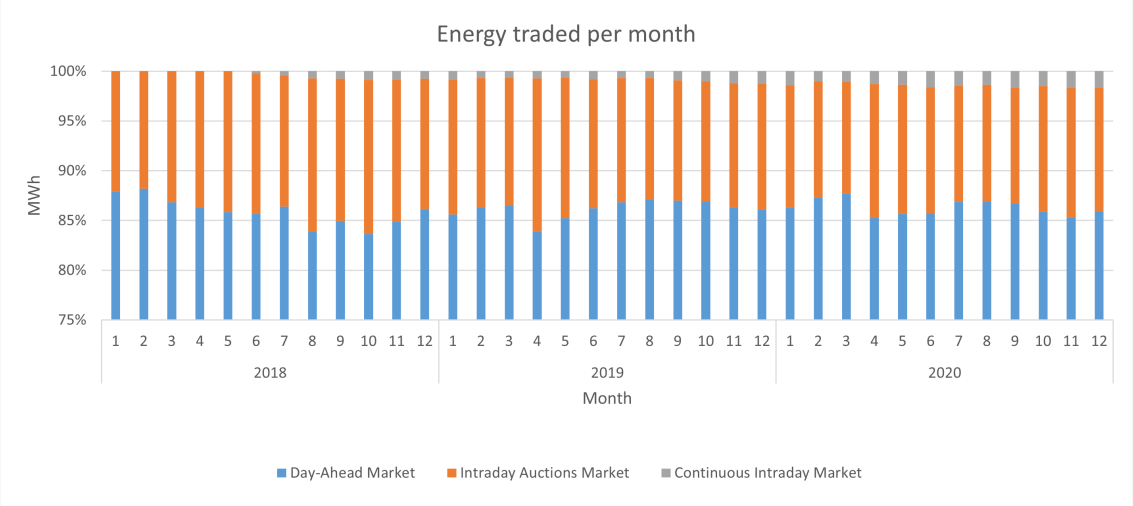

Figure 4.41: Percentile evolution of the total volume of traded energy per month in each market for 2018, 2019 and 2020

Through Figure 4.41 we can verify that the total share of traded energy through the Continuous Intraday Market is increasing every month steadily, meaning that agents are using it more and more for their normal transactions due to the flexibility it provides.

4.5.2 Hourly analysis

Figures 4.42, 4.43 and 4.44 represent the average amount of traded energy per hour in the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market, respectively, over the years in study.

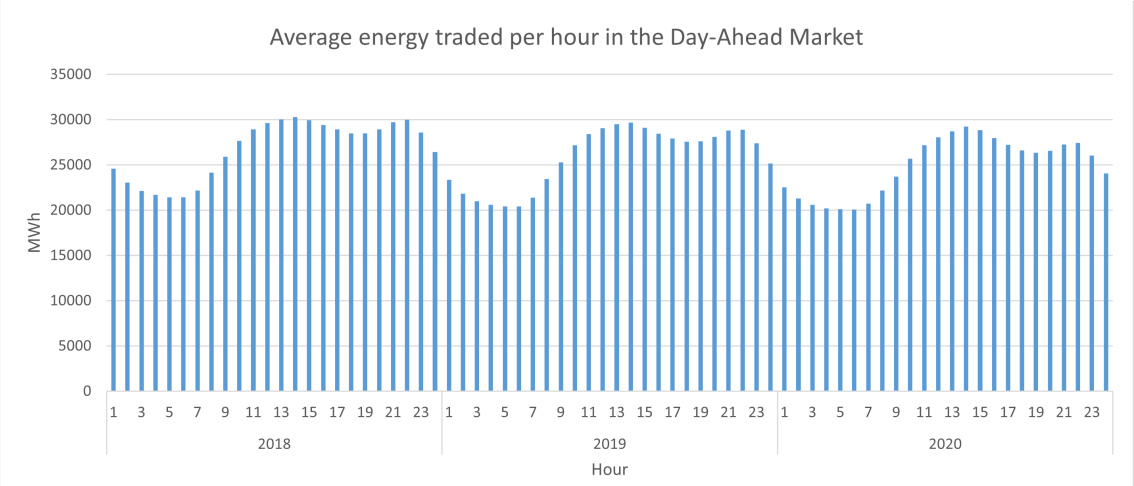

Figure 4.42: Evolution of the average traded energy per hour in the Day-Ahead Market for 2018, 2019 and 2020

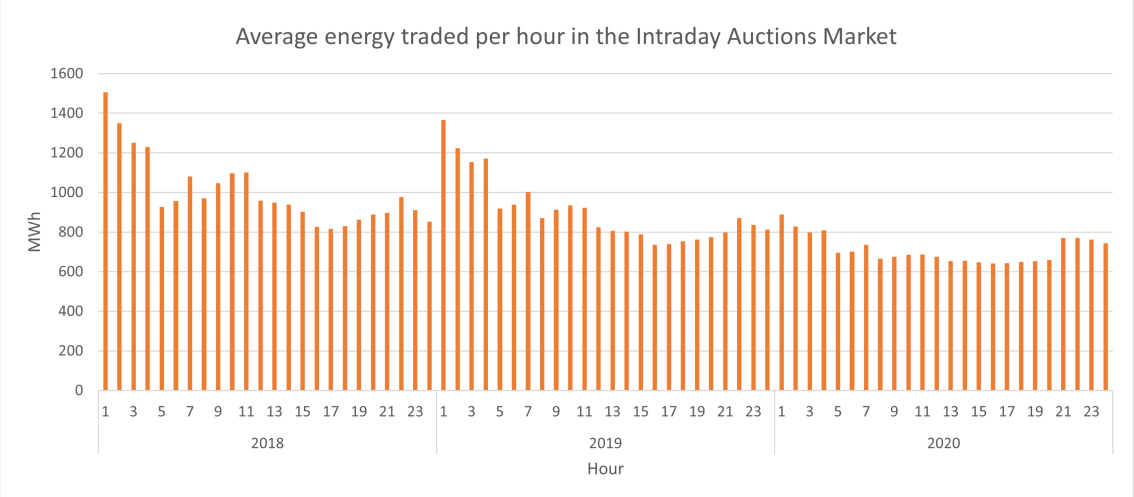

Figure 4.43: Evolution of the average traded energy per hour in the Intraday Auctions Market for 2018, 2019 and 2020

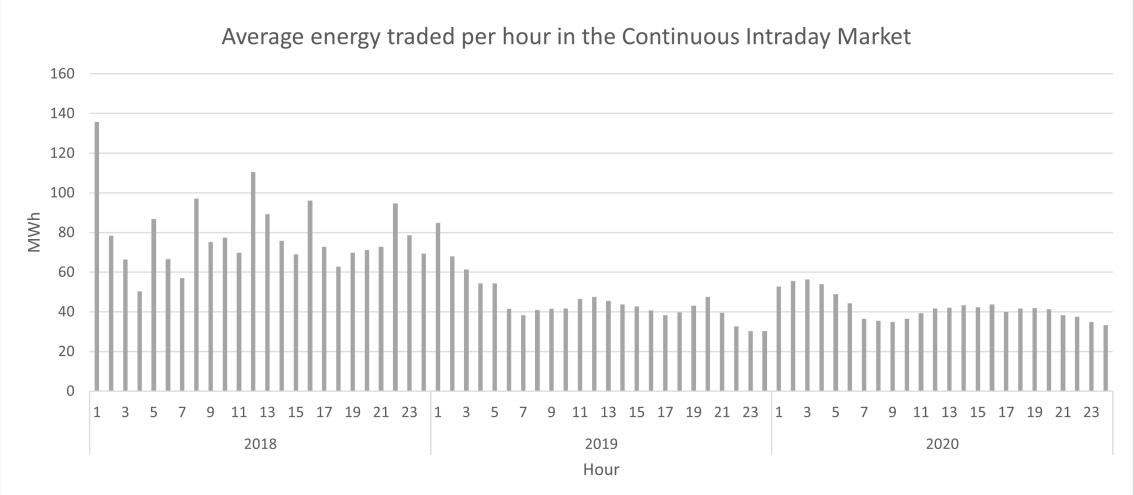

Figure 4.44: Evolution of the average traded energy per hour in the Continuous Intraday Market for 2018, 2019 and 2020

In Figure 4.43 we can notice higher values of traded energy in the first four hours of the day for 2018 and 2019, while in 2020 everything appears to be more balanced with only a slight increase in the hours of lower demand, where there is less traded energy in the Day-Ahead Market.

For the Continuous Intraday Market, through Figure 4.44 it is possible to observe the impact that the change on its operation model, addressed in chapter 2, had from 2018 to 2019. In fact, in 2018 the average traded energy values peaked in the first hour of each contract right after the Intraday Auctions Market sessions, and for 2019 and 2020 these values are way more balanced throughout the day. This means that the Continuous Intraday Market follows the Day-Ahead Market trend with the exception of the hours with lower demand, where it behaves like the Intraday Auctions Market.

4.5.3 Analysis on the sessions and rounds

For the Intraday Auctions Market, it is also possible to observe the impact of the change in scheduled horizons for each session through the difference in the trend of traded energy in the years of 2018, 2019 and 2020. Figures 4.45 and 4.46 represent the average amount of traded energy per session, and per hour in each session of the Intraday Auctions Market for the years in study.

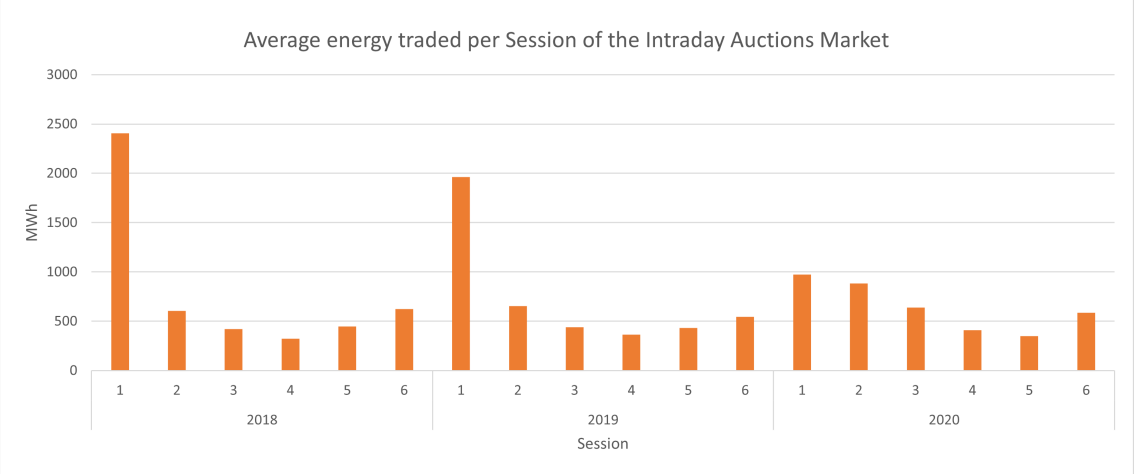

Figure 4.45: Evolution of the average traded energy per session of the Intraday Auctions Market for 2018, 2019 and 2020

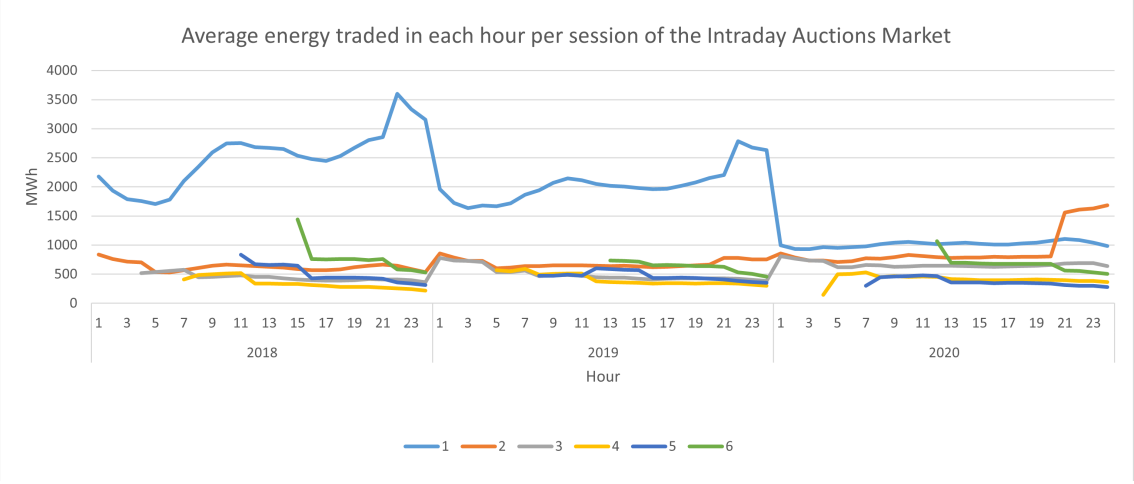

Figure 4.46: Evolution of the average traded energy per hour in each session of the Intraday Auctions Market for 2018, 2019 and 2020

It can be concluded that 2018 and 2019 follow the same trend, but 2020 records overall lower values of traded energy in session 1, and an increase in the last four hours of the day for session 2. This difference can be explained due to the change introduced in the schedule horizons mentioned previously.

Finally, Figure 4.47 shows the evolution of the average volume of traded energy per round, and Figure 4.48 shows the evolution of the average volume of traded energy per hour in each round of the Continuous Intraday Market for 2018, 2019 and 2020.

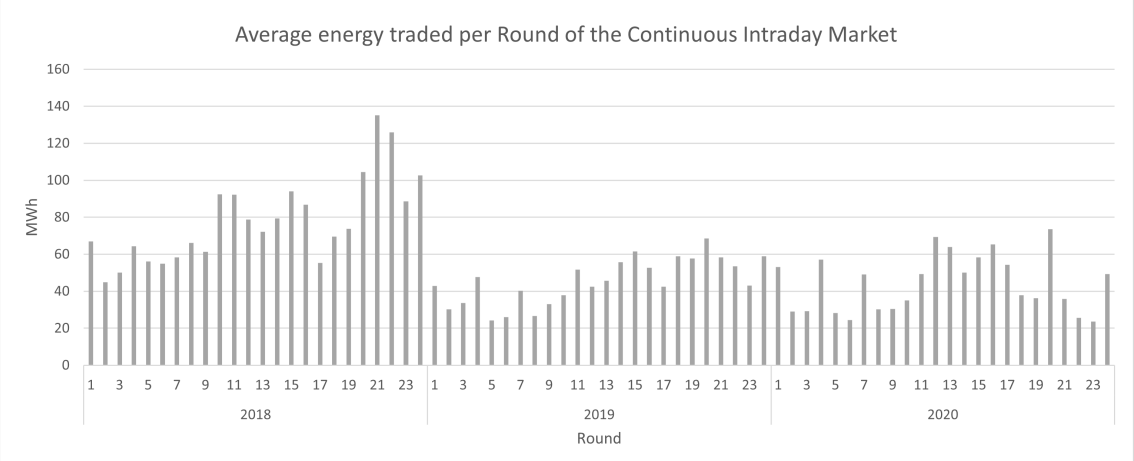

Figure 4.47: Evolution of the average traded energy per round of the Continuous Intraday Market for 2018, 2019 and 2020

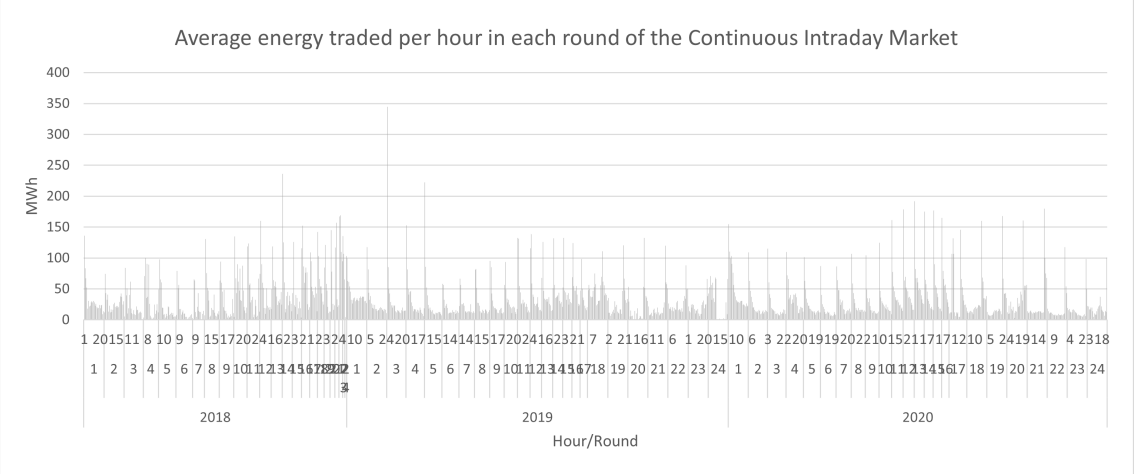

Figure 4.48: Evolution of the average traded energy per hour in each round of the Continuous Intraday Market for 2018, 2019 and 2020

Through Figure 4.47 it is possible to observe that there is more traded energy for the hours with higher demand. On the other hand, Figure 4.48 shows the largest amount of traded energy per round is for the hours closer to the delivery time of the opening round contract.

Chapter 5

Analysis of the Clearing Agents and influence of the Generation Technologies

5.1 Introduction

After analysing both the energy prices and the volumes of the traded energy in all three markets for the years of 2018, 2019 and 2020, this chapter covers the top ten clearing agents and also the influence of different generation technologies in each market for the years in study.

For this analysis it is necessary to assess the data provided publicly in the web page of the Iberian Market Operator, OMIE, which can be found in the following references [21, 22]. And the unit lists for both Portugal [23] and Spain [24]. This data was processed with the help of Microsoft Excel and its Power Query feature.

Every single unit that contained bids was matched with the unit list in order to find out its owner company and what technology they are assigned to. In the occasion that an unit could not be matched to a type of technology, due to the lack of information in the unit lists provided by the Market Operators, it was grouped in an "unknown" status and then discarded if it didn't influence the overall trend of the graphics to a great extent.

5.2 Top ten agents

5.2.1 Day-Ahead Market agents

Figures 5.1 and 5.2 represent a pie chart with the share of the market per owner of generation bid units, and per owner of purchasing bid units, respectively, in the Day-Ahead Market.

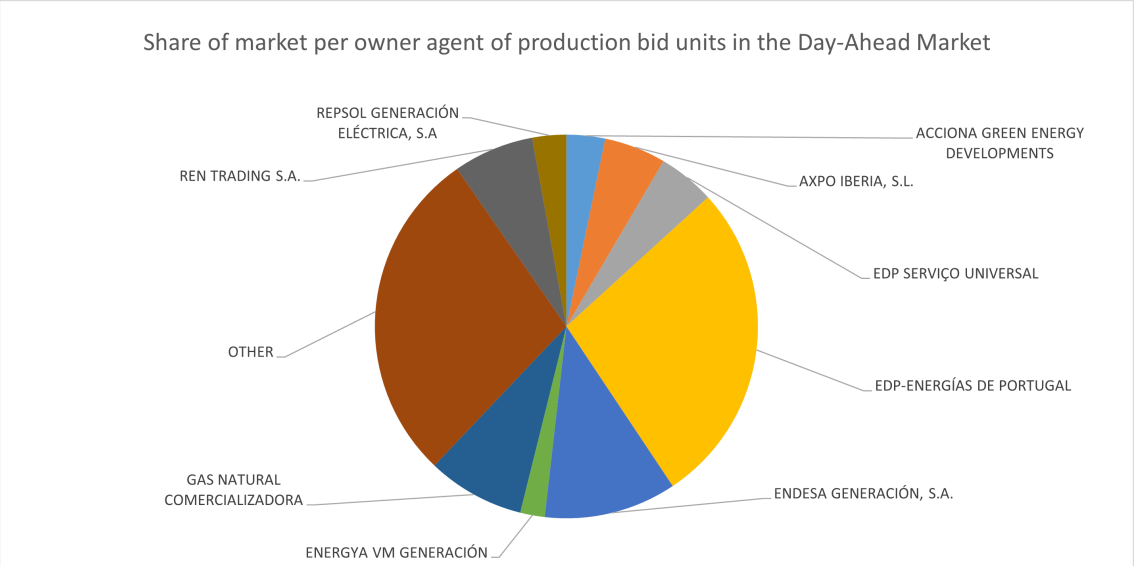

Figure 5.1: Share of the Day-Ahead Market per owner agent of generation bid units in 2018, 2019 and 2020

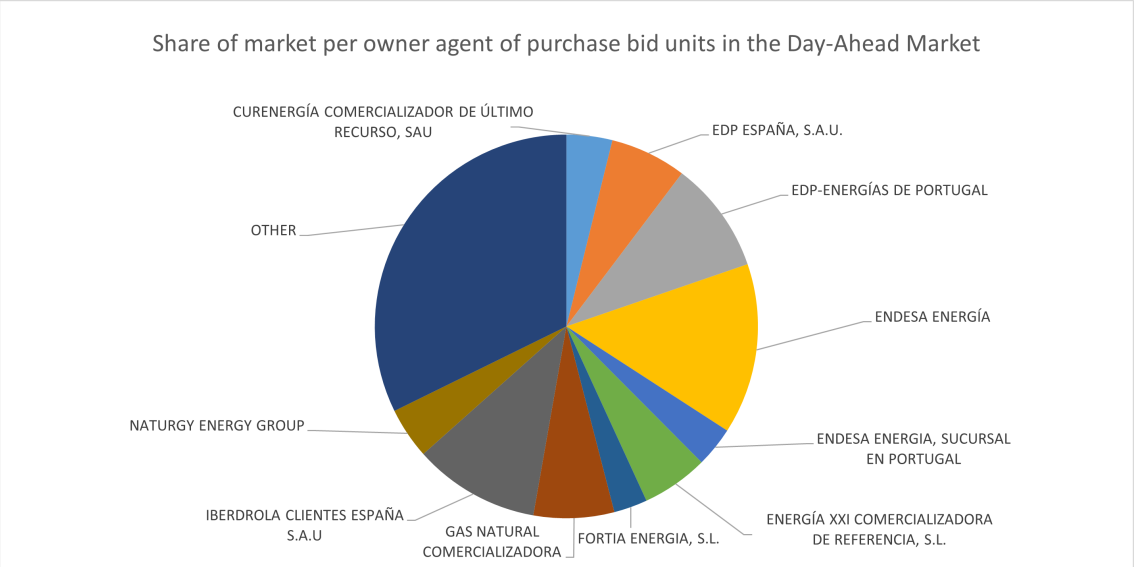

Figure 5.2: Share of the Day-Ahead Market per owner agent of purchase bid units in 2018, 2019 and 2020

5.2.2 Intraday Auctions Market agents

Figures 5.3 and 5.4 show the share of the Intraday Auctions Market per owner agent of generation or purchasing bid units respectively.

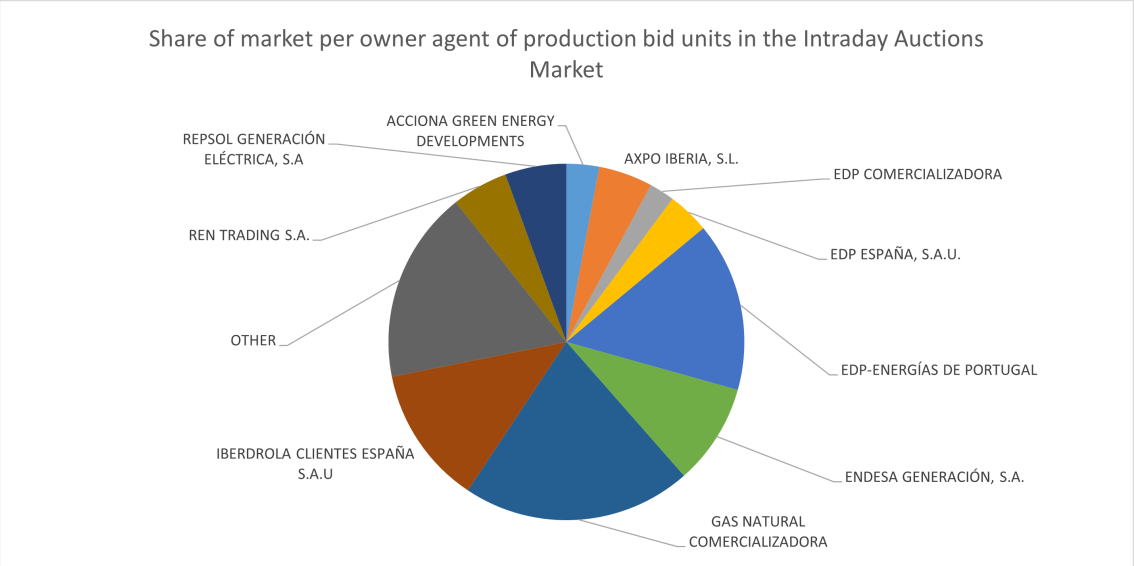

Figure 5.3: Share of the Intraday Auctions Market per owner agent of generation bid units in 2018, 2019 and 2020

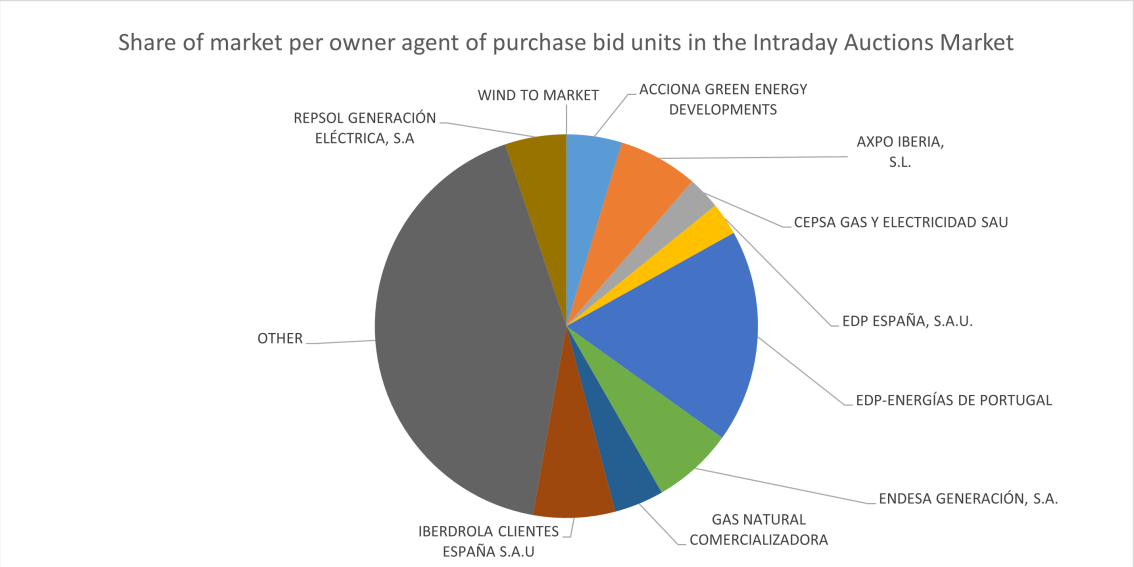

Figure 5.4: Share of the Intraday Auctions Market per owner agent of purchase bid units in 2018, 2019 and 2020

5.2.3 Continuous Intraday Market agents

Similarly to the other two markets, the share of the Continuous Intraday Market per owner agent of generation or purchasing bid units is presented in Figures 5.5 and 5.6 respectively.

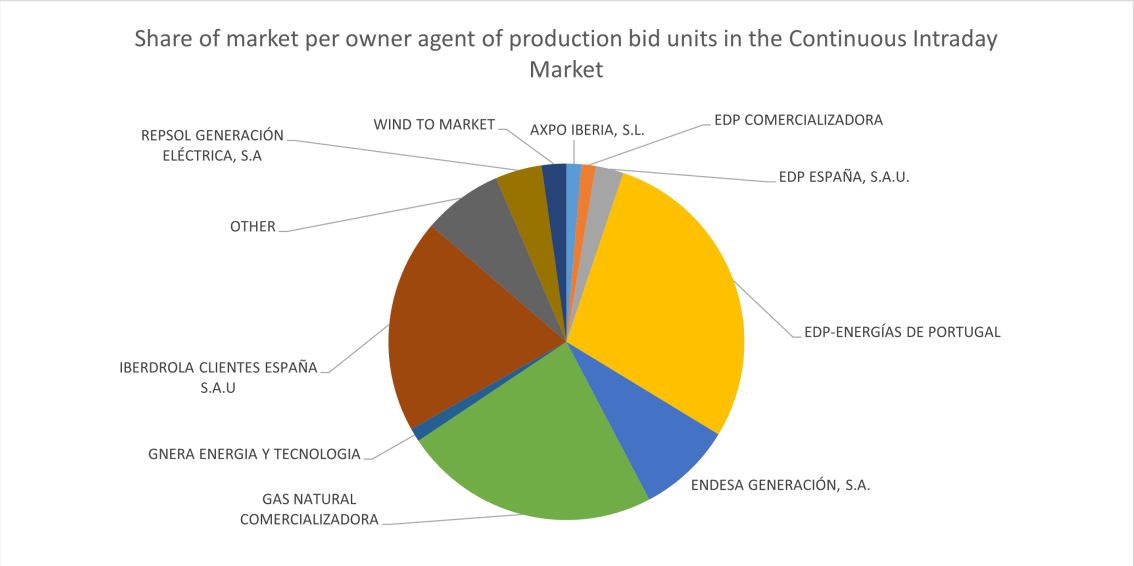

Figure 5.5: Share of the Continuous Intraday Market per owner agent of generation bid units in 2018, 2019 and 2020

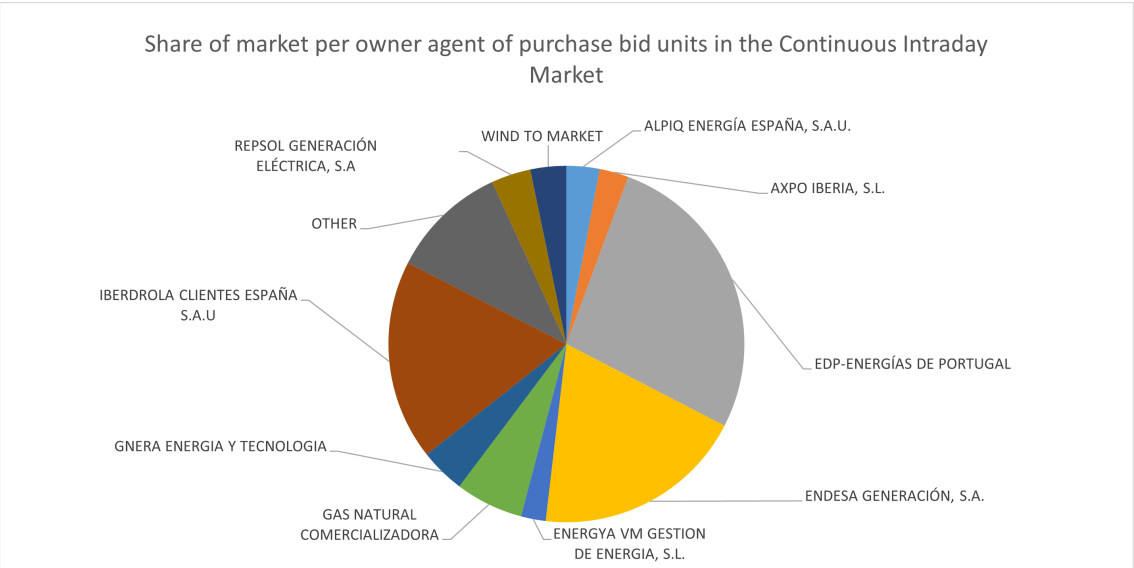

Figure 5.6: Share of the Continuous Intraday Market per owner agent of purchase bid units in 2018, 2019 and 2020

5.3 Influence of generation technologies

5.3.1 Analysis for 2018

The evolution of the volumes of energy generated by type of technology for 2018 is shown in Figures 5.7, 5.8 and 5.9 for the Day-Ahead Market, the Intraday Auctions Market and the Continuous Intraday Market respectively.

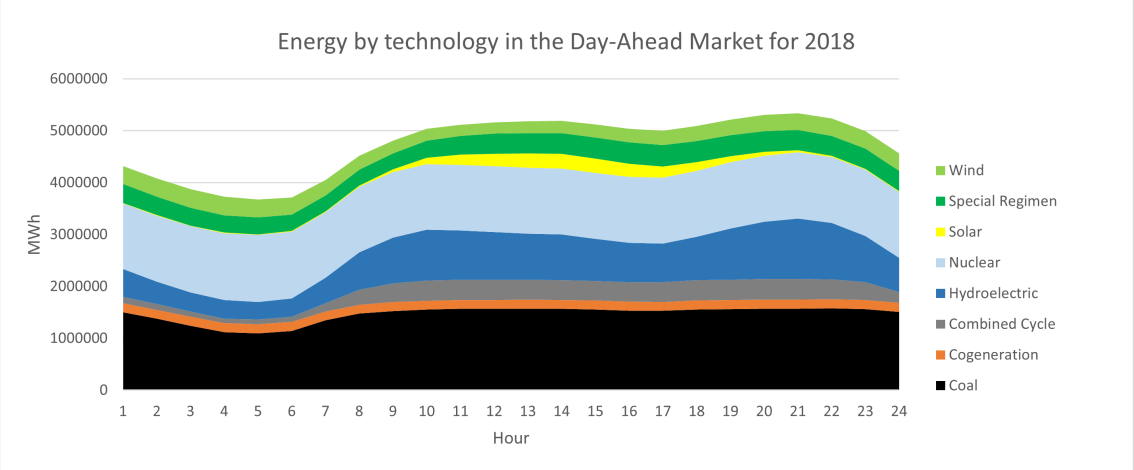

Figure 5.7: Total energy generated in each hour by technology for the Day-Ahead Market in 2018

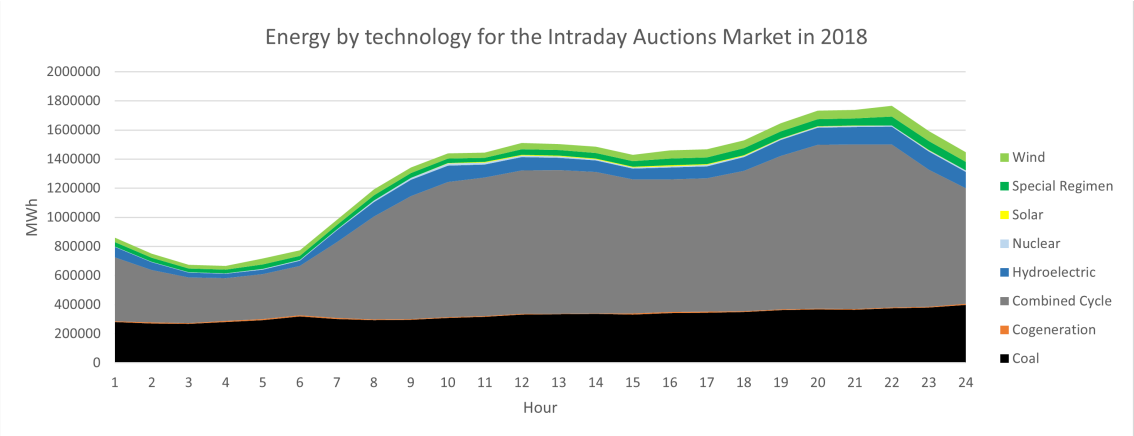

Figure 5.8: Total energy generated in each hour by technology for the Intraday Auctions Market in 2018

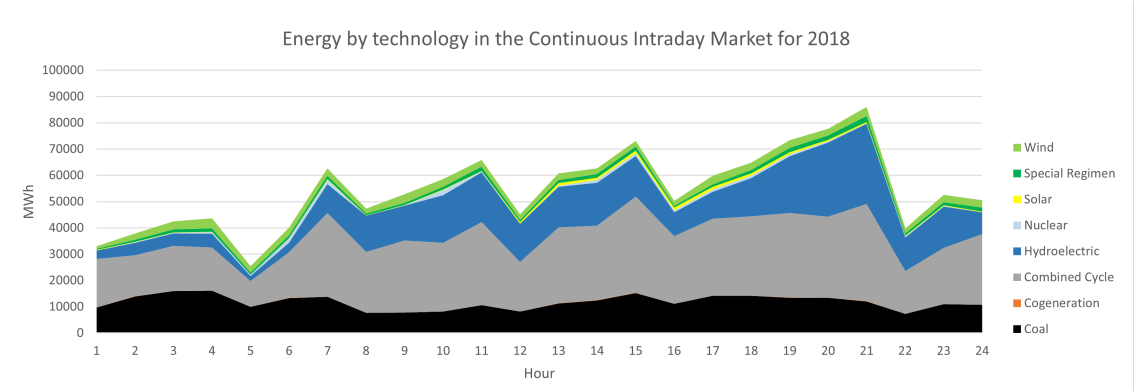

Figure 5.9: Total energy generated in each hour by technology for the Continuous Intraday Market in 2018

It is possible to observe that the Intraday Markets present lower values of energy generated by Nuclear or Cogeneration technologies in comparison with the Day-Ahead Market. Figure 5.8 shows that the Intraday Auctions Market main source of energy comes from Combined Cycle generation units. The Continuous Intraday Market also records high values of generation due to the Combined Cycle technology, and due to Hydroelectric generation, as it can be observed in Figure 5.9.

5.3.2 Analysis for 2019

In 2019, Figure 5.10 shows that the Day-Ahead Market recorded a decrease in Cogeneration and Coal technologies, and a major increase in the Combined Cycle generation.

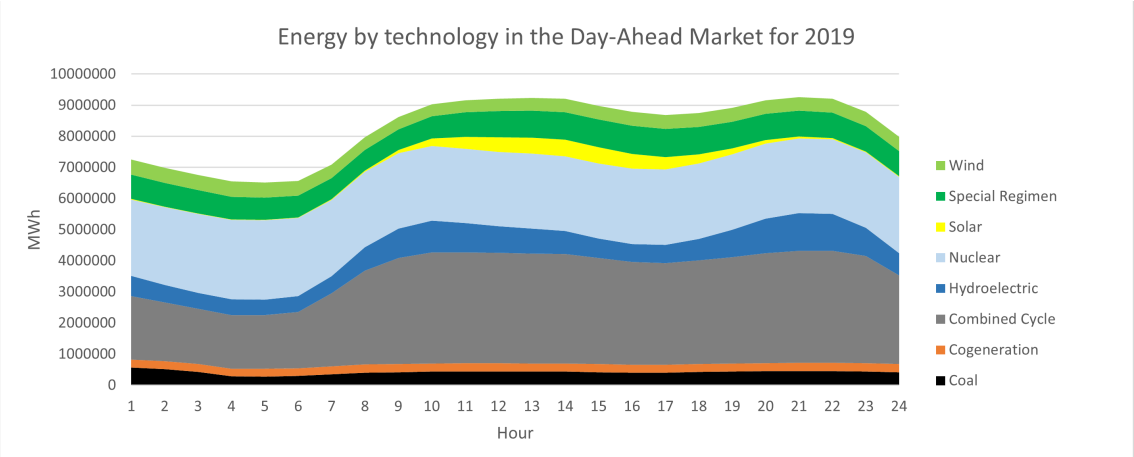

Figure 5.10: Total energy generated in each hour by technology for the Day-Ahead Market in 2019

Figures 5.11 and 5.12 show the evolution of energy generation by type of technology for the Intraday Auctions Market and the Continuous Intraday Market.

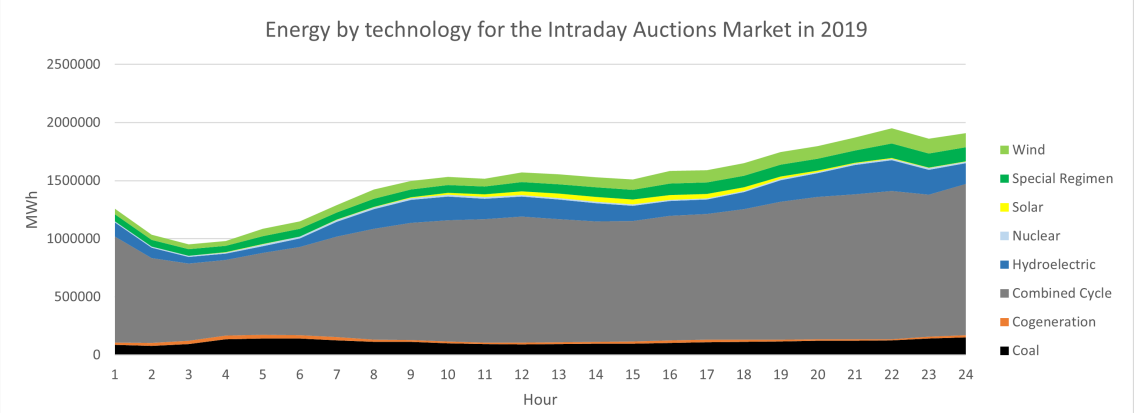

Figure 5.11: Total energy generated in each hour by technology for the Intraday Auctions Market in 2019

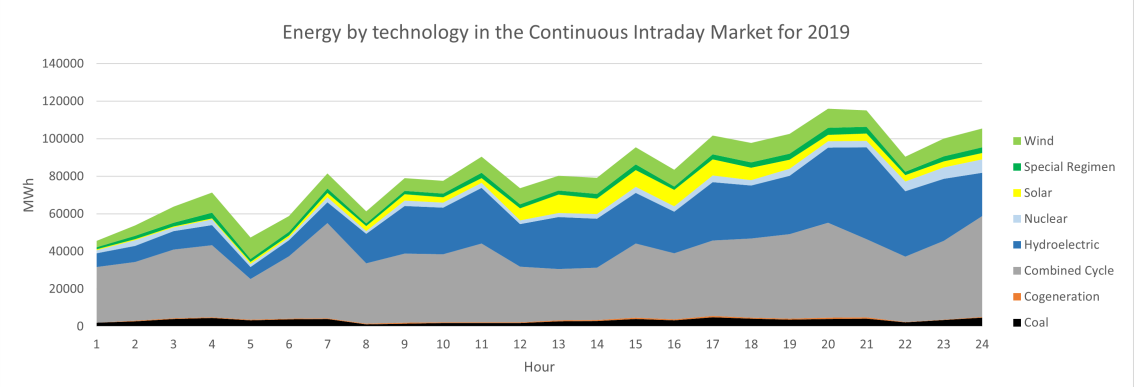

Figure 5.12: Total energy generated in each hour by technology for the Continuous Intraday Market in 2019

Both Intraday Markets recorded a decrease in generation using Coal technology, and an increase in more greener generation technologies such as Wind and Solar.

5.3.3 Analysis for 2020

Finally in 2020, all markets presented a significant decrease in generation coming from Coal and Cogeneration technologies, and an increase in energy generated from renewable sources such as wind, solar and water. This evolution can be observed in Figures 5.13, 5.14 and 5.15.

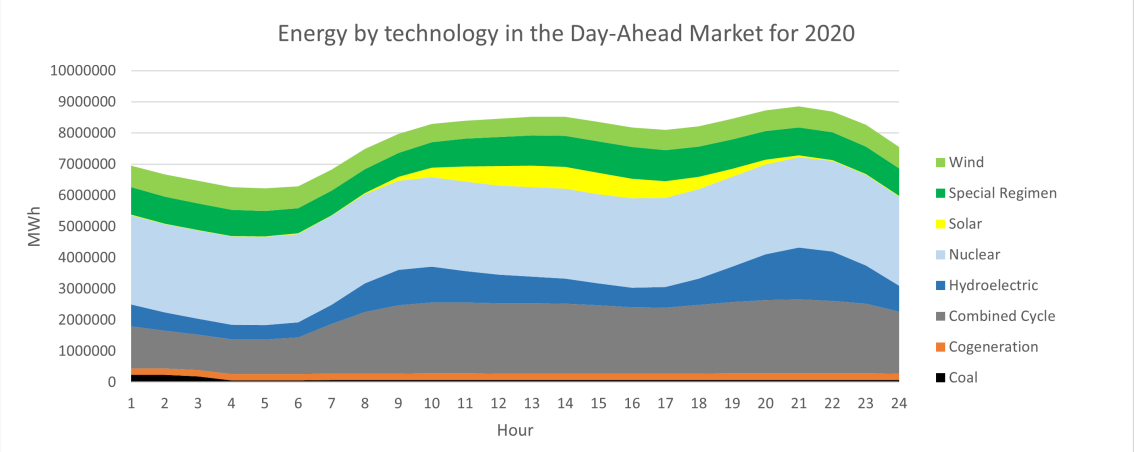

Figure 5.13: Total energy generated in each hour by technology for the Day-Ahead Market in 2020

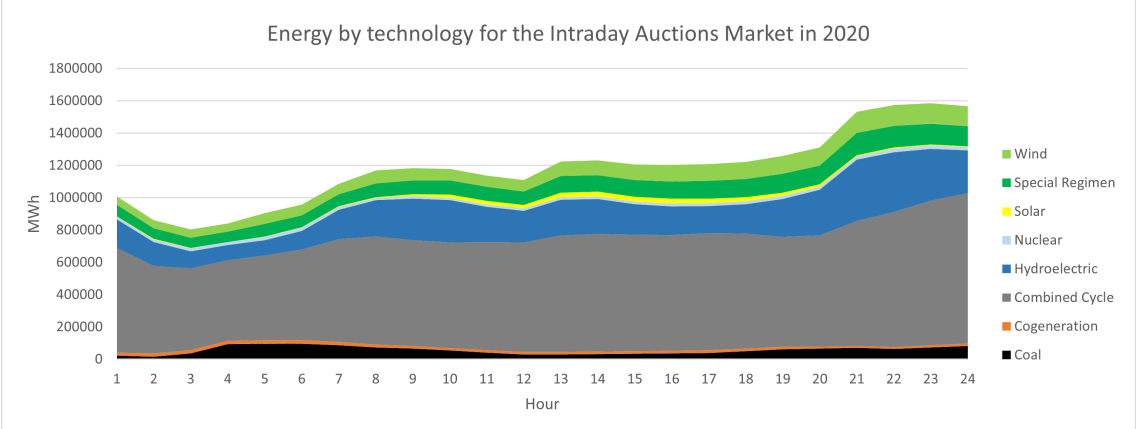

Figure 5.14: Total energy generated in each hour by technology for the Intraday Auctions Market in 2020

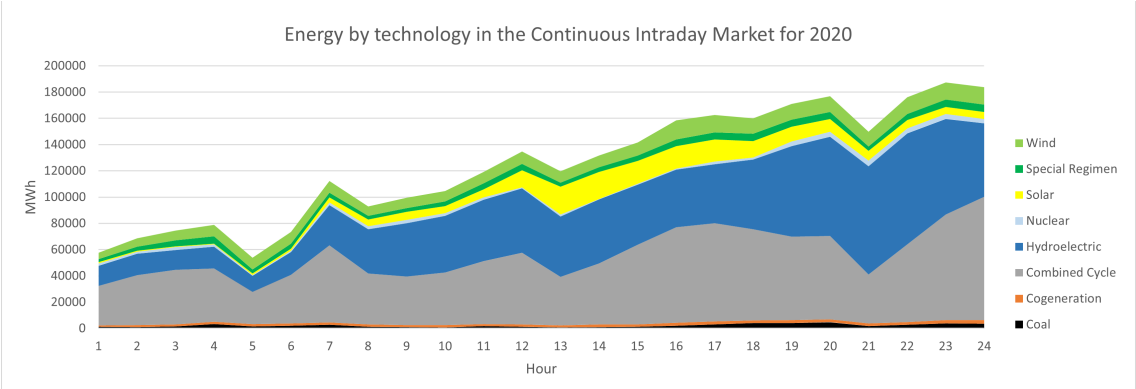

Figure 5.15: Total energy generated in each hour by technology for the Continuous Intraday Market in 2020

Chapter 6

Final considerations

6.1 Conclusions

The conclusions regarding the analysis of the results of the Intraday Auctions Market and the Continuous Intraday Market of the MIBEL are presented below.

The average yearly prices for the Intraday Auctions Market were 64,31 €/MWh in 2018, 48,05 €/MWh in 2019 and 34,47 €/MWh in 2020. There is a decrease of the average price over the years that can be explained due to a decrease in traded energy and an increase in renewable energy generation throughout these years. The Continuous Intraday Market, on the other hand, recorded an increase in the traded energy whilst also recording a decrease in average energy prices, which can also be explained by the increase in renewable energy generation. The average yearly prices for the Continuous Intraday Market were 63,22 €/MWh, 47,24 €/MWh and 33,68 €/MWh in 2018, 2019 and 2020 respectively. The average prices of each Intraday Market follow the trend of the Day-Ahead Market average prices throughout the years with a maximum deviation of +1,34 €/MWh in December 2020 for the Intraday Auctions Market and -2 €/MWh in December 2018 for the Continuous Intraday Market. In general the Intraday Auctions Market recorded the largest average energy prices and the Continuous Intraday Market recorded the lowest average energy prices of all three markets. Regarding session prices in the Intraday Auctions Market, sessions 5 and 6 represent the sessions closer to the delivery hours where there is more energy demand and where there is lower liquidity, resulting in the largest average prices. The Continuous Intraday Market also had the largest maximum prices and the lowest minimum prices in comparison with the other markets due to the fact that its transactions are made closer to delivery time, which means that this market is always used to solve unexpected deviations in the programs that resulted from the other two markets.

In terms of volume of traded energy, the values for the Intraday Auctions Market were 37357 GWh, 34088 GWh and 31081 GWh for 2018, 2019 and 2020 respectively, showing a decrease in volume of traded energy throughout the years that follows the trend of the MIBEL as a whole. This decrease in traded energy results from the decrease in energy consumption in both Portugal and Spain throughout the years in study. The Continuous Intraday Market recorded values of 1030

GWh in 2018, 2179 GWh in 2019 and 3534 GWh in 2020 for traded energy. Even though there was an increase in traded energy for this market, it only represents around 1% of the total traded energy in the MIBEL, while the Intraday Auctions Market represents around 13% and the Day-Ahead Market the other 86%. It was possible to observe an increase in traded energy in colder and warmer months for all markets, due to these being the periods with higher energetic demands due to climacteric reasons. There was also a decrease in traded energy in weekends and holidays since the demand for energy in those days is also at its lowest. Regarding the Intraday Auctions Market, session 1 was the session with the largest amount of traded energy in all three years, reducing its share with the other sessions after the change in the schedule where session 2 became the session with the largest scheduled horizon, but still having the largest amount of traded energy.

The agent, owner of production bid units, with the largest share in the Intraday Auctions Market for the last three years was Gas Natural Comercializadora and in the Continuous Intraday Market it was EDP-Energias de Portugal. Regarding purchasing bid units, the agents with the largest share in the market was EDP-Energias de Portugal for both of the Intraday Markets. Regarding the influence of different types of production technologies, both Intraday Markets have shown an increase in greener production technologies such as hydroelectric, solar and wind throughout the years.

6.2 Suggestions for future work

In the course of this study, it was possible to see that the intraday markets are still undergoing changes in both their structure and limits.

It would be interesting to study in more detail the borders with France and Morocco, the border capacity management markets, the different types of products traded in the Continuous Intraday Market and how each of these impact the MIBEL.

It would also be important to improve the database of units, with their respective technology, to obtain more refined results when addressing the influence of generation technologies in each market.

Finally, due to the short life span of the continuous intraday market, and the fact that one of those years already corresponded to the global pandemic situation, a new analysis of the intraday markets would be interesting to be made over the next years in order to confirm or to adjust the main conclusions that were now obtained.

Appendix A

Appendix

A.1 Previous Intraday Auctions Market Sessions

In Intraday Auctions Market there are 6 additional sessions where agents modify their program by presenting offers of sale and acquisition of energy so that there are less differences with reality such that the old scheduled horizons in each session are presented in Table A.1. [25, 14]

Table A.1: Previous hourly distribution per session [6]

Operativa anterior 12/11/2019		SESIÓN 1ª	SESIÓN 2ª	SESIÓN 3ª	SESIÓN 4ª	SESIÓN 5ª	SESIÓN 6ª
APERTURA DE SESIÓN		17:00	21:00	1:00	4:00	8:00	12:00
CIERRE DE SESIÓN		18:50	21:50	1:50	4:50	8:50	12:50
CASACIÓN Y PUBLICACIÓN		18:55	21:55	1:55	4:55	8:55	12:55
HORIZONTE DE PROGRAMACIÓN		27 horas	24 horas	20 horas	17 horas	13 horas	9 horas
(Periodos horarios)		(22-24 y 1-24)	(1-24)	(5-24)	(8-24)	(12-24)	(16-24)

Operativa a partir de 12/11/2019	SESIÓN 1ª	SESIÓN ~~1ª~~ 2ª	SESIÓN ~~2ª~~ 3ª	SESIÓN ~~3ª~~ 4ª	SESIÓN ~~4ª~~ 5ª	SESIÓN ~~5ª~~ 6ª	~~SESIÓN 6ª~~
APERTURA DE SESIÓN	14:00	17:00	21:00	1:00	4:00	~~8:00~~ 9:00	~~12:00~~
CIERRE DE SESIÓN	15:00	~~18:50~~ 17:50	21:50	1:50	4:50	~~8:50~~ 9:50	~~12:50~~
CASACIÓN Y PUBLICACIÓN	15:07	~~18:55~~ 17:57	~~21:55~~ 21:57	~~1:55~~ 1:57	~~4:55~~ 4:57	~~8:55~~ 9:57	~~12:55~~
HORIZONTE DE PROGRAMACIÓN	24 horas D+1	~~27~~ 28 horas	24 horas	20 horas	17 horas	~~13~~ 12 horas	~~9 horas~~
(Periodos horarios)	(1-24)	(~~22~~ 21-24 y 1-24)	(1-24)	(5-24)	(8-24)	(~~12~~ 13-24)	~~(16-24)~~

AEO LA ENERGÍA QUE NECESITAS

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A.2 Intraday Markets Models A and B

The differences are that in the temporary hybrid Model A, you can re-negotiate the hours of the Day-Ahead Market or the Intraday Auctions Market that already happened until the next Intraday Auctions Market session arrives. While in the definitive Model B, you can negotiate the remaining hours before the one hour delivery begins. [6]

Figures A.1 and A.2 represent the scheduled horizons of each model respectively.

	Sesión 1.ª	Sesión 2.ª	Sesión 3.ª	Sesión 4.ª	Sesión 5.ª	Sesión 6.ª
Apertura de Recepción de ofertas	17:00	21:00	01:00	04:00	08:00	12:00
Cierre de Recepción de ofertas	18:40	21:40	01:40	04:40	08:40	12:40
Horizonte de programacion . . . . (Periodos horarios).	27 horas (22-24 y 1-24)	24 horas (1-24)	20 horas (5-24)	17 horas (8-24)	13 horas (12-24)	9 horas (16-24)

MODELO A

Figure A.1: Scheduled horizons and important times of Model A [6]

	Sesión 1.ª	Sesión 2.ª	Sesión 3.ª	Sesión 4.ª	Sesión 5.ª	Sesión 6.ª
Apertura de Recepción de Ofertas.	17:00	21:00	01:00	04:00	08:00	12:00
Cierre de Recepción de Ofertas.	18:50	21:50	01:50	04:50	08:50	12:50
Horizonte de programación . . . . (Periodos horarios).	27 horas (22-24 y 1-24)	24 horas (1-24)	20 horas (5-24)	17 horas (8-24)	13 horas (12-24)	9 horas (16-24)

MODELO B

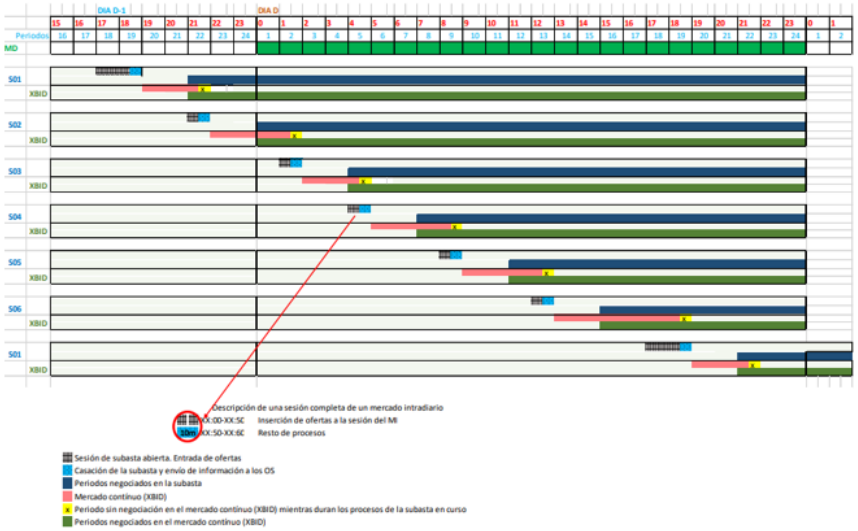

Figure A.2: Scheduled horizons and important times of Model B [6]

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